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Offshore Environmental
Studies Program

OCS Statistical Series
MMS 89-0070

Environmental Studies Index

(Atlantic Outer Continental Shelf,
Second Edition)

MMS U.S. Department of the Interior
Minerals Management Service
Atlantic OCS Region

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OCS Statistical Series
MMS 89-0070

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Studies Program

Environmental Studies Index

(Atlantic Outer Continental Shelf, Second Edition)

Compiled by:
Judith M. Wilson

U.S. Department of the Interior
Minerals Management Service
Atlantic OCS Region

Herndon, Virginia
1989

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Preface

The Environmental Studies Program began in 1973, under the Bureau of Land Management (BLM), to support the Department of the Interior's oil and gas leasing program on the Outer Continental Shelf (OCS). The objective of the program has been to "establish information needed for prediction, assessment, and management of impacts on the OCS and the nearshore area which may be affected..." (43 CFR 30001.7). In May 1982, this program, along with all leasing and resource management functions of the OCS, was consolidated and placed within the Minerals Management Service (MMS). The OCS functions within the MMS are divided into four regions: Alaska, Atlantic, Gulf of Mexico, and Pacific. In the Atlantic Region, four planning areas exist: North Atlantic, Mid-Atlantic, South Atlantic, and Straits of Florida. The Environmental Studies Unit of the Atlantic Region develops proposed study programs issued as Regional Studies Plans for each fiscal year. These study plans outline proposed research programs which are intended to:

> provide information on the status of the environment upon which the prediction of the affect of OCS oil and gas development may be based;
>
> provide information on the ways and extent that OCS development can potentially impact the human, marine, biological, and coastal area;
>
> ensure that information already available or being collected under the program is in a form that can be used in the decisionmaking process associated with a specific leasing action or with the longer term OCS minerals management responsibilities; and
>
> provide a basis for monitoring future OCS operations, including assessments of short-term and long-term impacts attributable to the OCS oil and gas program.

Approved studies are funded as contracts and awarded to a variety of qualified research groups. Past and ongoing contracts have produced numerous technical reports, maps, data banks, and other products for use in the planning and management of OCS activities.

United States Department of the Interior
Minerals Management Service
Atlantic OCS Region
Parkway Atrium Building
381 Elden Street
Herndon, Virginia 22070-4817

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Introduction

Introduction

This document is a summary of environmental studies that have been funded and managed for the Department of the Interior by the Atlantic Region. Many of these studies are specific to one or more Atlantic planning areas (North, Middle, South, Straits of Florida, Fig. 1-4) while some are "national studies", with results applicable to all OCS Regions. For most studies, a limited number of final reports are produced directly for the MMS. This initial supply of reports is distributed under a standard distribution system known as the Studies Program Information and Management System (SPIMS) as well as in response to requests from interested parties. One copy of each report is also available for review at the MMS Atlantic Region Office in Herndon, Virginia. In addition, most reports can be purchased from the National Technical Information Service (NTIS) at the following address:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Each study is issued as a contract or an interagency agreement (IA). Contracts/IA's issued under the BLM are identified by a 5-character prefix (e.g., AA550), followed by the type of study (MU or IA for interagency agreements, CT for contract) and fiscal year awarded (e.g., 6=1976, 0=1980, 2=1982). The final number indicates the specific contract awarded in a given fiscal year (e.g., CT8-46 is the 46th contract awarded in FY 1978). In 1982, all active contracts were placed within the MMS. All MMS contracts have an 8-character prefix (14-12-0001-) followed by a specific identification number (e.g., 30025). Contracts awarded under the BLM and still active in May 1982 have dual designations (e.g., CT1-39/29188). For convenience, the prefix codes are not repeated when studies are referred to in this summary.

Each study abstract lists useful information in a standard format of up to 18 headings.

Title: Lists the initial contract or program title. This often differs from the final report title.

Date: Lists the date of contract award and close-out.

Cost: Lists actual cost of the contract.

Prime Contractor: Lists the name and address of the prime contractor as stated in the contract. IA's will list the Federal Agency.

Subcontractors/Cooperating Institutions: List includes official subcontractors for services and/or technical performance, affiliations of consultants, and organizations cooperating in the study without direct payment for services.

Chartered Research Vessels: Lists vessels subcontracted under the study for field research.

Program Manager: Lists the administrative head or principal scientist for the study. Unless otherwise noted, affiliation is with the prime contractor.

Principal Participants: Lists chief scientists and/or key administrative persons conducting the study. For larger, complex studies this list may be restricted to group or section leaders and omit staff scientists.

Contracting Officer: Lists the BLM/MMS officer responsible for administration of the contract. If reassignment occurred during the study a chronological list of contracting officers is presented.

COTR: Lists the BLM/MMS Contracting Officer's Representative responsible for technical monitoring of the study. Where applicable, a chronological list is given.

Key Words: Lists descriptive terms used in the Environmental Studies Database (ESDS) for the purpose of indexing contracts and reports. The ESDS key words are limited to relatively broad topics or special items of particular concern to the MMS OCS Program.

Objectives: Lists study objectives stated at contract award. Additional objectives added through modification of the contract are noted. These objectives are initial program goals which may or may not be reflected in actual study results.

Summary: Lists major findings of original research or the major contents of literature compilation efforts.

Final Report: Lists the title of the official contract final report(s) submitted to the BLM/MMS followed by the authors and year.

Availability: Lists the NTIS reference number for the final report or notes special cases.

Other Publications/Reports: Lists publications and related reports making use of study data. These often represent individual efforts of the authors to further elaborate on results obtained under the BLM/MMS contract.

Other Related Contracts Within This Study Program: Individual contracts often represent 1-year efforts or a specific technical task within a broader program (e.g., South Atlantic

Geological Studies, Georges Bank Monitoring Program). For these cases all related contracts are listed at the end of the abstract.

Figures: When maps for a particular contract have been included, they have been taken from the Final Report submitted to the BLM/MMS.

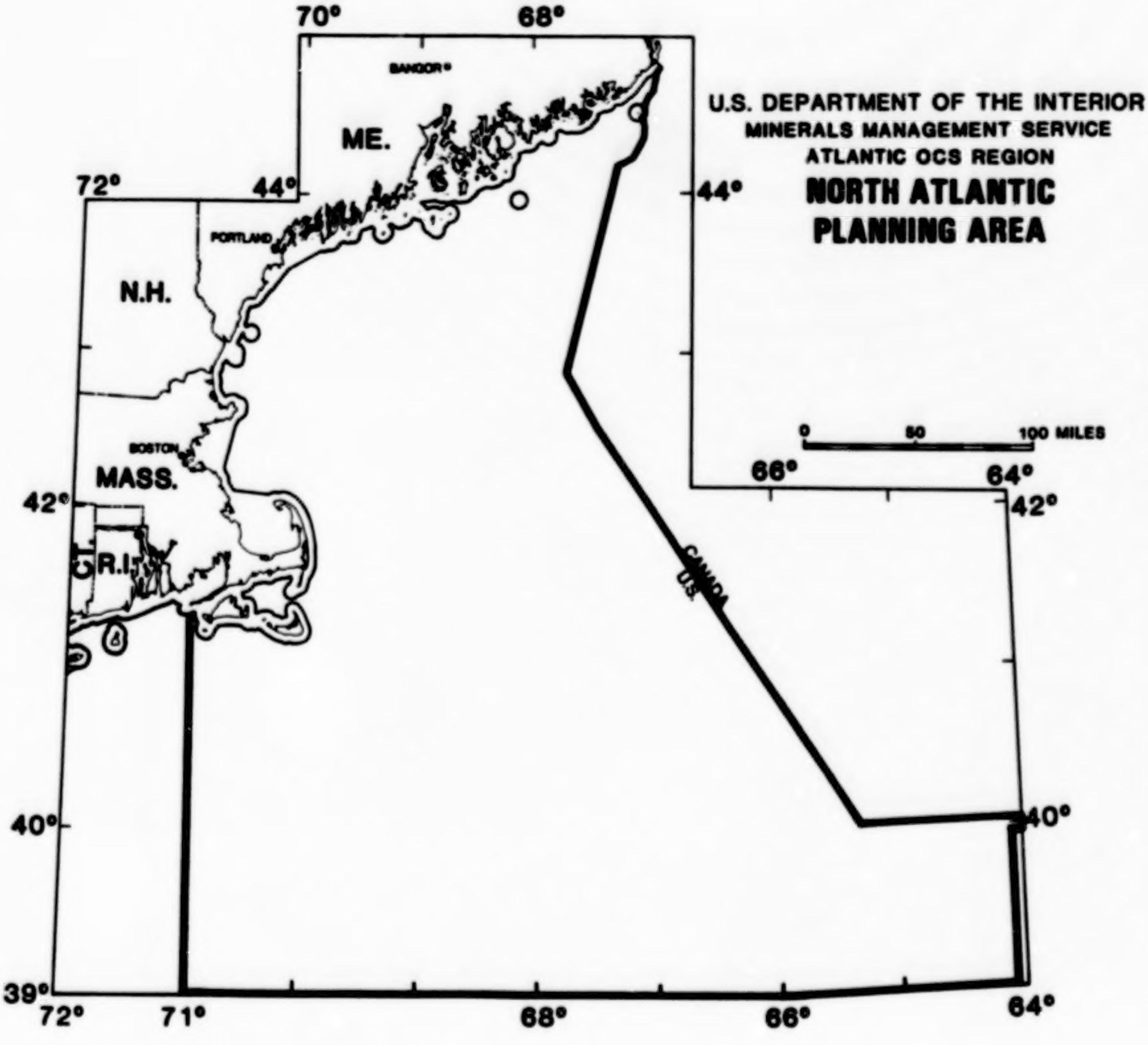

Figure 1. North Atlantic Planning Area.

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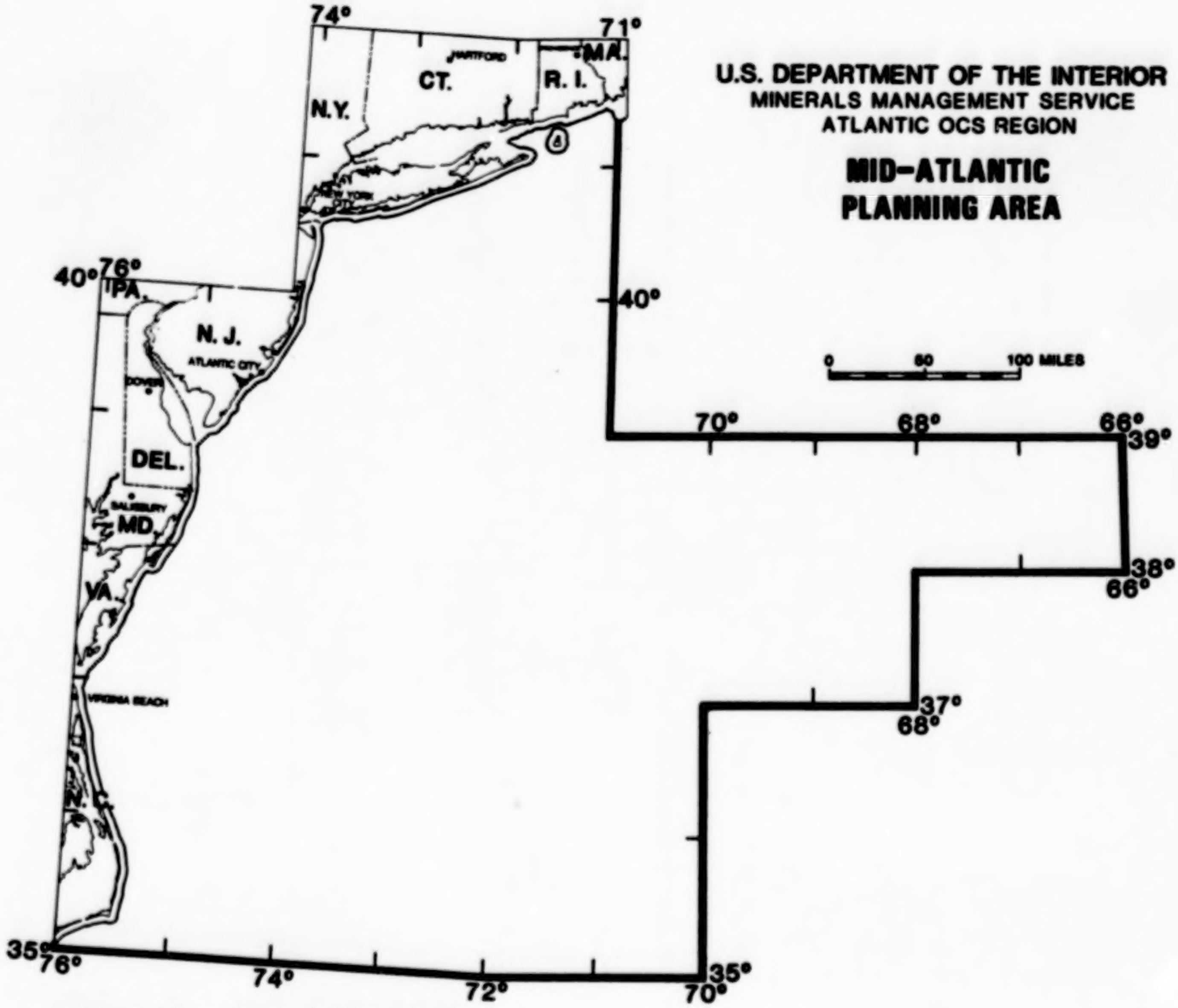

Figure 2. Mid-Atlantic Planning Area.

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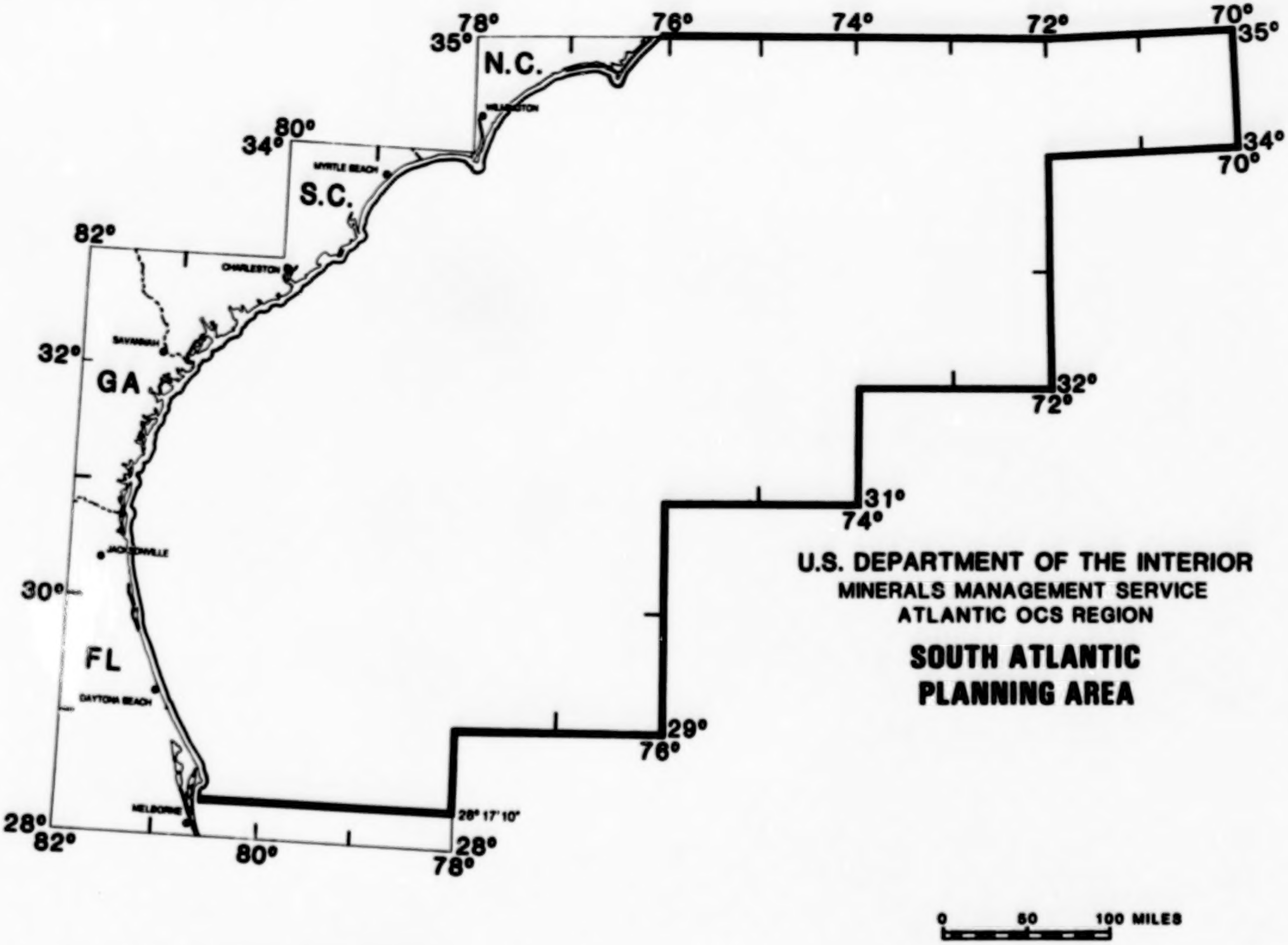

Figure 3. South Atlantic Planning Area.

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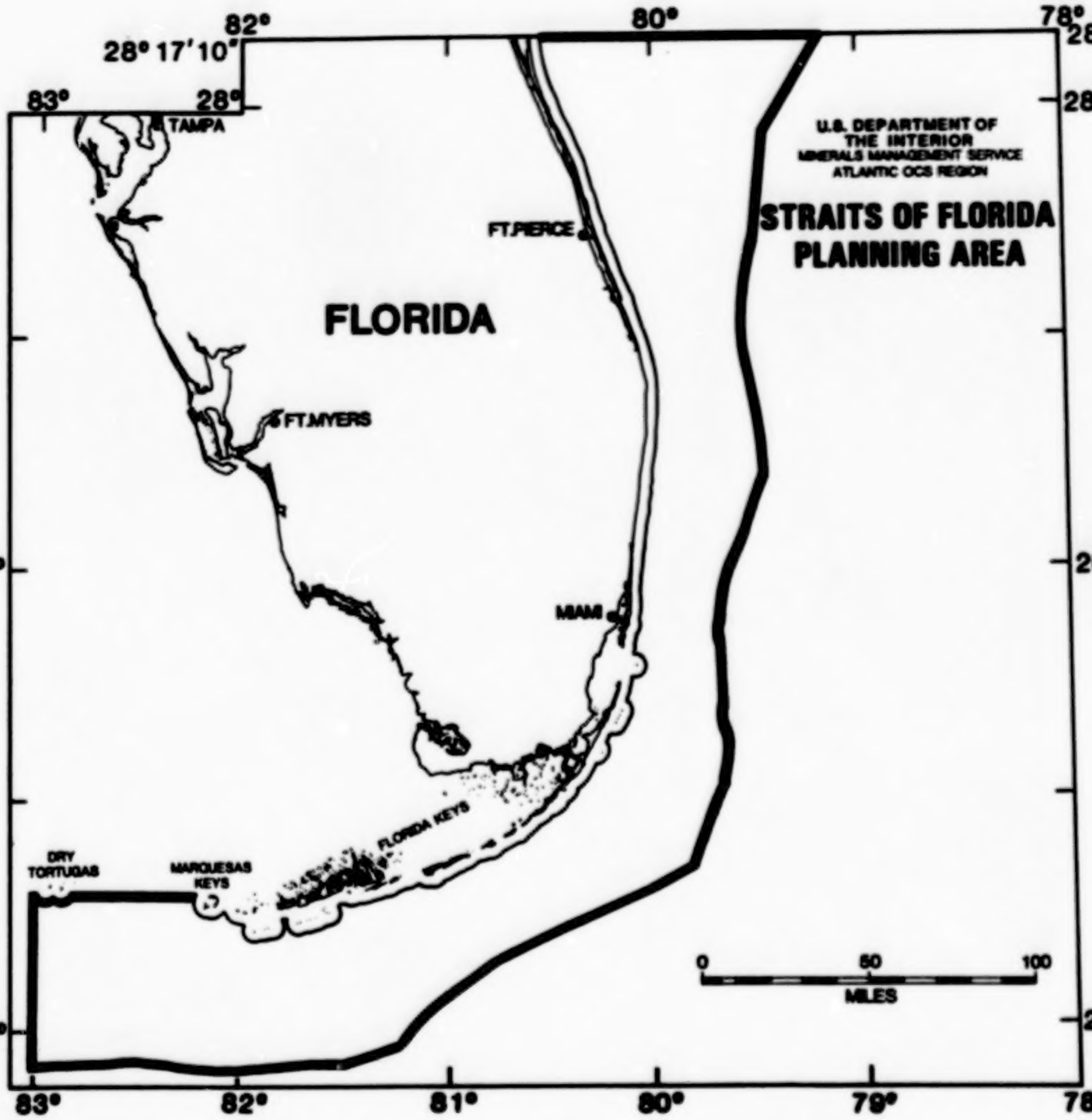

Figure 4. Straits of Florida Planning Area.

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Environmental Studies Index

North Atlantic

Workshops and Conferences

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BLM CONTRACT NO: **08550-CT5-29**

Title: Public Conference and Workshop on Georges Bank

Date: 21 April 1975 - 22 May 1975

Cost: $19,770

Prime Contractor:
New England Natural Resources Center (NENRC)
506 Statler Building
Boston, Massachusetts 02116

Program Manager:
Charles H. Foster (Conference Chairman)

Contracting Officer:
Vernon F. Ehlerding

COTR: Frank Basile

Key Words:
Georges Bank study; conferences/meetings/symposiums; geology-general treatment; hazards-geologic sediment characteristics; trace metals; transport (physical processes); characterization-ecological; oil and gas resources

Objectives:

1. Provide a summary of available related information and understanding for a portion of the continental shelf designated by the Minerals Management Service (MMS) in the Atlantic region.

2. Provide any predictions, presently possible of the effects of drilling (including both exploration and exploitation) on the environment of this area.

3. Identify the areas of knowledge in which additional information is essential for reasonable prediction and understanding of the environmental effects of drilling in this area.

4. Formulate recommendations for baseline and monitoring programs adequate for determination of the environmental effects of any oil and gas exploration and exploitation in this area.

Summary:
The Georges Bank Conference was convened to identify environmental assessment needs related to petroleum exploration and development. The Conference broke into four workshop groups (Biological Oceanography, Chemical Oceanography, Geological Oceanography, and Physical Oceanography), to discuss study needs and types of studies needed. The workshop groups then broke into smaller subgroups for

more detailed discussions. The major conclusions of the workshop groups and subgroups were presented.

The Biological Oceanography Workshop broke into five subgroups: energy pathways, statistical limits, marine mammals and birds, effects and events, and physiology. The subgroups determined that baseline surveys of the seasonal and geographical distribution of primary production and studies of the benthos, zooplankton, neuston and phytoplankton were needed and feasible. The energy pathways subgroup recommended research on the role and fate of hydrocarbons in the environment. The statistical limits subgroup determined that before the needed survey of the nekton was conducted an acceptable survey technique would have to be developed. The marine mammals and birds subgroup concluded that there was a lack of databases, including life histories, for many species. The effects and events subgroup recommended a survey of fauna, physiological and behavioral studies, and monitoring to detect changes in trophic relationships. The physiology subgroup recommended that the species selected for study be economically important, abundant, amenable to live study in the laboratory, sensitive to pollution, and representative of different modes of living, eating, and of wide-spread distribution.

The Chemical Oceanography Workshop was broken into three subgroups: biochemical pathways, petroleum components, and trace metals. The biochemical pathways subgroup decided that definitions of biologically significant events and the primary nutrient cycle need to be developed and the modifications of biological processes due to oil exploration need to be evaluated. The petroleum components subgroup concluded that before the needed baseline study can be conducted an analytical methodology needed to be developed to determine the concentration, composition and location of petroleum components in the environment. The trace metals subgroup determined that baseline metal concentrations needed to be determined and that the data should be directly pertinent in terms of possible biological impact.

The Geological Oceanography Workshop was divided into three subgroups: sediment transport, seismic risk, and engineering properties of shallow sediments. The sediment transport subgroup recommended baseline studies of bottom sediment properties, of particulate flux, and of shoal and nonshoal areas to determine particle movement. The seismic risk subgroup identified the need to determine the present seismic activity and to correlate this current activity with tectonic structures. The engineering properties subgroup suggested a regional reconnaissance of geologic engineering properties to evaluate possible hazards.

The Physical Oceanography Workshop was broken into four subgroups: transport, coastal climatology, vertical mixing, and water mass characteristics and distribution. This workshop group identified the need to resolve the routes, reactions, and rates involved in the passage of contaminants or pollutants through the Georges Bank region and the reservoirs in which they may be found.

The conference concluded that a baseline environmental assessment program was needed. Numerous subgroup members pointed to the fact that research vessel time should be shared and multi-interest cruises undertaken. The need for a program manager who would coordinate all efforts was identified.

Final Report:

Georges Bank Conference, marine environmental assessment needs on the Georges Bank related to petroleum exploration and development. (NENRC; 1975).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

MMS CONTRACT NO.: 14-12-0001-30430

Title: Submarine Canyon Workshop for the North Atlantic

Date: September 1988 - June 1989

Cost: $115,608

Prime Contractor:

Walcoff and Associates, Inc.
635 Slaters Lane, Suite 102
Alexandria, Virginia 22314

Subcontractors/Cooperating Institutions:

Exxon Production Research Company (EX)
Arthur D. Little Inc. (AL)
U.S. Geological Survey (USGS)
University of Connecticut (UC)
Woods Hole Oceanographic Institute (WHOI)
Lamont-Doherty Geological Observatory (LDGO)
Rutgers University (RU)
Massachusetts Coastal Zone Management Program (MCZM)
Battelle Ocean Sciences (BOS)
Shell Oil (SO)
Rhode Island Department of Administration, Division of Planning (RI)

Program Manager:

Katherine Bayly

Principal Participants:

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John Kraeuter (RRU)
James Lane (MMS)
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Robert Miller (MMS)
Jerry Neff (BOS)
James Ray (SO)
John Teal (WHOI)
Page Valentine (USGS)
Bruce Vild (RI)

Contracting Officer:

Carolyn Golden

COTR: Robert E. Miller

Key Words:

sediments (geology); geology, submarine canyons; benthic studies; effects of oil, hydrocarbons; conference

Objectives:

1. Summarize the existing knowledge on the sediment transport and depositional processes within and adjacent to the submarine canyons of the North Atlantic continental slope through invited presentations by scientists and other professionals.

2. Develop an assessment of the following two hypotheses: a) "In submarine canyons of the North Atlantic margin where erosional environments exist, there is a low probability of serious environmental impact to faunal assemblages from oil and gas activities in the vicinity of the canyon heads."

   b) "In submarine canyons of the North Atlantic margin where depositional environments may exist, the rate of accumulation of drilling related contaminants is slow enough not to present serious environmental risks to faunal assemblages from oil and gas activities in the vicinity of the canyon heads."

   Special emphasis should be placed on: a) assessing the impact, if any, that potentially toxic metals and hydrocarbons associated with suspended sediments may have on benthic epifaunal communities, b) evaluating the influence that varying volumes of operational discharges of oil from platforms or well blowouts may have on benthic communities.

Summary:

There are nine major submarine canyons along the southern flank of Georges Bank, and several smaller ones. The canyons are special biological habitats. Physical and biological features are complex and heterogeneous - within canyons and between canyons. Two canyons, Lydonia and Oceanographer, have been studied in detail. Lydonia is a smaller, primarily low-energy environment where deposition of fine-grained sediments occurs. Oceanographer is larger, relatively high-energy, with erosional scouring and little deposition.

The canyon heads, particularly those with boulder fields and "pueblo villages" are habitats and nursery grounds for commercial species that include tilefish and lobsters. Attached filter-feeding fauna are common in some areas.

Metals and other contaminants from exploratory drilling are unlikely to cause environmental impacts beyond the vicinity of the wellsite. Many contaminants are in forms biologically unavailable to marine organisms.

An oil spill would primarily cause surface-layer impacts affecting fish eggs and larvae. Water-column impacts are unlikely. Transport of oil to the bottom may occur, primarily in shallow water. Transport mechanisms for oil are unknown, but may include adsorption onto sinking fine sediments and particles ("scavenging"), including krill fecal pellets. Chemical effects on settling larvae may be more important than physical effects on the benthos.

Workshop recommendations and findings include: 1) no rigs should be placed within 500 m of canyon boundary; 2) "worst-case" calculations indicated contaminants from drill site 500 m from a canyon are unlikely to cause impacts; 3) oil content of produced water must meet discharge standards, with environmental monitoring of any oil and gas production operations; and 4) there is insufficient information on possible impacts from gas blowouts.

Final Report:

Proceedings of the North Atlantic submarine canyons workshop: February 7-9, 1989. Summary synthesis. (MMS; 1989).

Proceedings of the North Atlantic submarine canyons workshop: February 7-9, 1989. Transcript. (MMS; 1989).

Availability:

Available from NTIS:

Vol. I PB89-207856/AS.
Vol. II PB89-207864/AS.

North Atlantic

Environmental Inventories and Assessments

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BLM CONTRACT NO.: 08550-CT5-47

Title: Inventory of Environmental Parameters of the Deep Atlantic Shelf and Slope from the Canadian/U.S. Border to Cape Hatteras, North Carolina.

Date: 24 June 1975 - 17 January 1977

Cost: $48,311

Prime Contractor:
The Research Institute of the Gulf of Maine (TRIGOM)
P.O. Box 2320
South Portland, Maine 04106

Subcontractor/Cooperating Institutions:
Maine Department of Natural Resources (MDNR)
New England Aquarium (NEA)
Public Affairs Research Center (PARC)
Westinghouse Oceanic Division (WOD)
College of the Atlantic (CATL)
University of Connecticut (U Conn)
University of New Hampshire (UNH)
University of Rhode Island (URI)
Woods Hole Oceanographic Institution (WHOI)

Program Managers:
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Edward H. Shenton

Principal Participants:
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Diane Brackett (TRIGOM)
Thomas Grigalunas (URI/PARC)
James Havens (URI)
Frank Heppner (URI)
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Contracting Officer:
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Fred Galinsky
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COTR: Eiji Imamura

Key Words:

literature search (bibliography); ecological characteristics; geology-general treatment; chemical analysis; benthic studies; circulation/current study

Objectives:
The contractor was to conduct a comprehensive literature search of published and unpublished information, current research, and impending environmental programs relating to the North and Mid-Atlantic continental slope, specifically the area between the 200 meter and 2,000 meter isobaths and the limits defined by the Canadian/United States border and Cape Hatteras, North Carolina.

The objectives of this study were to enable the Minerals Management Service to:

1. Compile information for the preparation of Environmental Impact Statements.
2. Provide a data base for the preparation of Environmental Study Plans.
3. Develop a comprehensive inventory of marine environmental information for decisionmaking purposes.
4. Identify gaps and deficiencies in the data base where further data gathering or research is required.

Summary:

The results of an environmental survey of the Mid-Atlantic and North Atlantic regions of the outer continental slope are described. This region is the area extending from Cape Hatteras, N.C. to the U.S./Canadian border and from the 200 to 2000 meter depth contours; however, many topic areas include information from the continental shelf break to the Gulf Stream. The continental slope is a complex feature representing the transition between two principal levels of the earth's surface, the low density rocks of the continent and the high density rocks of the ocean floor. In the northwest Atlantic, the slope width averages 100 km (62 mi). This relatively narrow band of ocean is a region of change. The geologic structure is a transitional one. The physical and chemical characteristics of the water are highly variable, reflecting the mixing between several major water masses: the coastal waters, Gulf Stream, Labrador Current and Western Boundary Undercurrent. The flora and fauna of the study region are highly diverse, representing a change between the shallow boreal shelf biota and the tropical and warm, temperate oceanic biota in the pelagic realm; and between the abundant, adaptive fauna of the shelf floor and the sparse, conservative fauna of the deep ocean floor in the benthic realm.

Final Report:

Summary of environmental information on the continental slope from the Canadian/U.S. border to Cape Hatteras, N.C. (TRIGOM; 1976).

Availability:

Available from NTIS:

- Final Report (Vol. I, Physical, Chemical & Geological Oceanography) - PB284001
- Final Report (Vol. II, Biological Oceanography) - PB284002
- Final Report (Vol. III, Human Influence) - PB284003
- Appendices (Vol. IV) - PB284004

CONTRACT NO. AA550-CT6-45

Title: A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras.

Date: 29 September 1976 - December 1977

Cost: $194,180

Prime Contractor:
Center for Natural Areas (CNA)
Box 98
South Gardiner, Maine 24359

Program Manager:
Edward H. Shenton
William Reed

Principal Participants (contributing authors & CNA staff):
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Philip Thomas

Key Words:
characterization-ecological; literature search (bibliography); effects of oil, hydrocarbons; trace metals; circulation/current study

Objectives:
The Contractor shall furnish the necessary personnel, services, materials and facilities to accomplish a summary and analysis of environmental information for the geographical areas from the Bay of Fundy to Cape Hatteras, North Carolina, from the spring tide mark to the 200 m isobath. Literature dating from the beginning of 1973 shall be examined for the region from the Bay of Fundy to Sandy Hook, New Jersey, and from the beginning of 1972 for the region from Sandy Hook, New Jersey to Cape Hatteras, North Carolina. The results from

this effort will emphasize data compilation, integration, analysis, and interpretation. The basic study objectives were as follows:

1. Provide published and unpublished materials, as well as data sources, which update marine environmental information presented in the documents produced by The Research Institute of the Gulf of Maine (TRIGOM) (1974) and University of Rhode Island (1972-1973).

2. Compile and integrate both laboratory and field data concerning the effects of petroleum hydrocarbons and trace metals on marine organisms.

3. Summarize and document ongoing oceanographic survey and research programs.

4. Compile sources of raw data and unanalyzed samples.

5. Identify data gaps in each topic area and recommend future studies to fill the gaps.

Summary:
The final report was three volumes. Volume I consisted of 3 books with a total of twenty chapters. Each chapter dealt with an environmental topic consisting of a statement of data sources, data gaps, and recommended future studies. Recommendations for future studies were based on an assessment of available data and resulting data gaps.

In geology, there was a lack of information about the specific sediment supply budget of beach compartments, a lack of data concerning the general structural and stratigraphic configuration of the marine environment and a lack of data concerning sedimentary processes in the marine environment. Studies were recommended to fill these gaps and also gaps concerning beach systems, barrier island maintenance, and flood tidal deltas.

Meteorological studies should be aimed at constructing a vertical profile of wind and temperature, and studies of the sequence and duration of events. Physical oceanography studies should determine the driving mechanism of the counterclockwise and clockwise gyres.

Studies of the effects of oil and PCB levels on phytoplankton species were recommended. Zooplankton studies of the nutrition and metabolism of various species and their seasonal and areal distribution were recommended.

Studies of the neuston should include studies of the microorganisms present in the microlayers. Recommended studies of the nekton included collection of basic life history information for most fish species, determination of the relationship between species and the ecosystem, and standardizing procedures so that data from different studies would be comparable.

Recommended studies of commercial fisheries included the collection and processing of statistical information, analysis of socioeconomic data, and development of an adequate stock assessment technology. In sport fisheries, recommended studies included collection of statistical data and assessment of man's impact on resources.

Recommended studies of the benthos included studies of the dominance and distribution of organisms and collection of life history data. Recommended benthic flora studies included seasonal and long term studies of rocky shore algal communities and salt marsh flora.

Recommended marine mammal studies included a census of all species, diet studies, assessment of the ecological relationships, and determination of the areal and seasonal distribution of species.

Studies of marine birds were recommended including studies of the distribution of pelagic seabird species, the ecology of seabirds and the relationship between seabirds and man made structures.

Recommended endangered species studies included identification and determination of numbers and distribution of species, coordination and summarization of all data, and determination of the range and requirements of species.

Recommended toxicity and health studies included studies of bioaccumulation, acute toxicity, and sublethal effects.

Final Report:

A summary and analysis of environmental information on the continental shelf from Bay of Fundy to Cape Hatteras. (CNA; 1977).

Availability:

Available from NTIS:

- Final Report (Vol. I, Bk. 1, Geology, Meteorology, Physical Oceanography, Chemistry) - PB80-177462
- Final Report (Vol. I, Bk. 2, Neuston, Nekton, Benthos, Fisheries, Marine Mammals) - PB80-177470
- Final Report (Vol. I, Bk. 3, Birds, Endangered Species, Microbiology, OCS Uses) - PB80-177488
- Final Report (Vol. II, Master Bibliography, Index, Acknowledgements) - PB80-177496
- Appendices (Vol. III) - PB80-177504

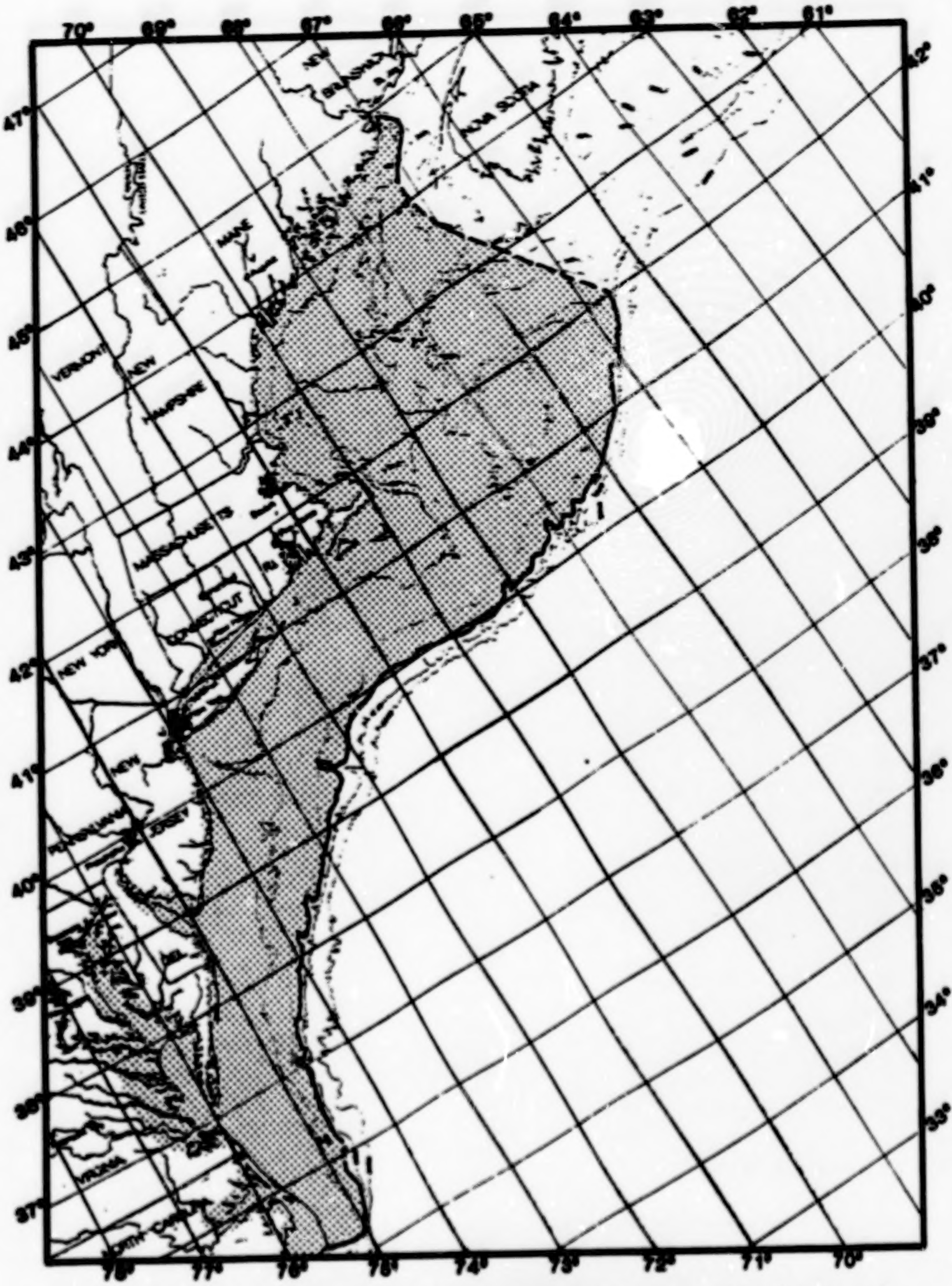

Figure 5. Location of study area for "A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras." (Source: BLM Contract No. AA550-CT6-45).

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BLM CONTRACT NO.: AA550-CT6-51

Title: New England Outer Continental Shelf Environmental Benchmark Study

Date: 19 August 1976 - 15 May 1978
(Terminated prior to completion of all tasks)

Cost: $4,302,416

Prime Contractor:
Energy Resources Company, Inc. (ERCO)
185 Alewife Brook Parkway
Cambridge, Massachusetts 02138

Subcontractors/Cooperating Institutions:
Battelle New England Marine Research Laboratories (BNEMRL)
Bigelow Laboratory (BL)
Laboratory Services Associates
Marine Research, Inc. (MRI)
Massachusetts Institute of Technology (MIT)
University of Delaware (UD)
University of Maine (UM)

Chartered Research Vessels:
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R/V Gyre
R/V Knorr

Program Manager:
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Principal Participants:
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Reinier Courant
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Mort Jangorbhani (MIT)
Peter Larson (BL)
Don Maurer (UD)
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Allan Michael (Taxon)
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Lowell Sick (UD)
Jeffrey Tinsman (UD)
Richard Toner (MRI)
Scott Warner (BNEMRL)
Leslie Watling (UM)
Chris Wethe (UD)
Dave Strimaitis

Contracting Officer:
William Hamm
Jeffrey P. Petrino

COTR: Kenneth Berger
Eiji Imamura

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Key Words:

hydrocarbons-chemical analyses; trace metals; benthic studies; characterization-ecological; microbes

Objectives:

1. Determine the ranges of high molecular weight (HMW) hydrocarbons and selected trace metal concentrations in the sediments and selected macrofauna species preceding oil and gas development as a baseline against which possible man-induced chemical change can be assessed in the future.

2. Delimit the major chemotopes, lithotopes, and biotopes for the study area, and characterize each with respect to natural seasonal variability and inter-relationships.

3. Characterize the existing health of selected benthic macrofauna preceding oil and gas development, and establish a histological data base that could serve as a reference for later comparisons.

4. Describe dominant microbes in sediments and in the upper water layers and evaluate their potential and possible importance in the degradation of oil.

5. Describe the HMW hydrocarbon and selected trace metal concentrations in the water column.

6. Identify and describe unique or fragile endangered areas.

7. Collect other data supportive of the above objectives.

Summary:

The Draft Final Report presents the initial findings of the first year's sampling efforts of the North Atlantic Outer Continental Shelf (OCS) program. Individual results are indicated in Volumes I and II. Appendices are listed in Volumes III, IV, and V.

Final Report:

New England OCS Environmental Benchmark draft final report. (ERCO; 1978).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS:
Final Report (Vol. I) - PB81-174906
Final Report (Vol. II) - PB81-174914
Appendix (Vol. III) -
Appendix (Vol. IV) - PB81-174922
Appendix (Vol. V) - PB81-186785

Other Publications/Reports:

Boehm, P.D., W.G. Steinhauer, D.L. Fiest, N. Mosesman, J.F. Barak, and G.H. Perry. 1979. A chemical assessment of the present levels and sources of hydrocarbon pollutants in the Georges Bank region. In: Proceedings 1979 Oil Spill Conference. pp. 333-341.

Larsen, P.F. and R.M. Lee. 1978. Observations on the abundance, distribution and growth of postlarval sea scallops, Placopecten magellanicus, on Georges Bank. The Nautilus 92:112-116.

Maurer, D. and W. Leathem. 1980. Ecological distribution of polychaetous annelids of Georges Bank. College of Marine Studies, University of Delaware, CMS-1-80, 181 p.

_______________. 1981. Polychaete feeding guilds from Georges Bank, USA. Marine Biology 62:161-171.

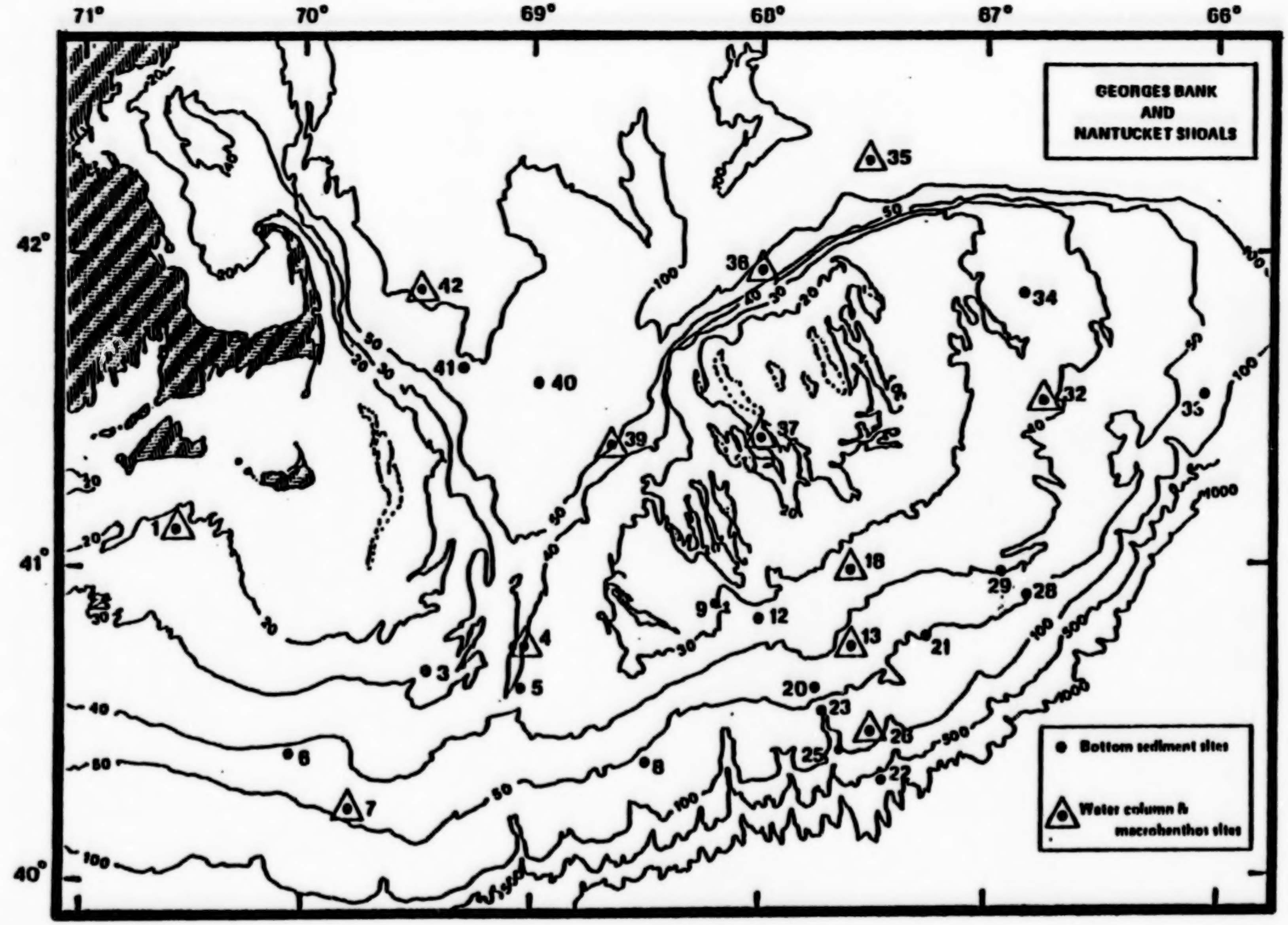

Figure 6. Station locations and coordinates. (Source: BLM Contract No. AA550-CT6-51).

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Environmental Studies Index

North Atlantic

Socio-economics

BLM CONTRACT NO.: 08550-CT3-08

Title: Socio-Economic and Environmental Inventory of the North Atlantic Region from Sandy Hook, New Jersey to the Bay of Fundy

Prime Contractor:

The Research Institute of the Gulf of Maine (TRIGOM)
P.O. Box 2320
South Portland, Maine 04106

Key Words:

social/economic survey; ecological characteristics; habitat description, identification

Objectives:

1. Develop a comprehensive inventory of marine environmental data for the coastal zone and adjacent waters of the outer continental shelf.

2. Conduct a study of the socio-economic factors operating in the region from the Bay of Fundy (Eastport, Maine) to Sandy Hook, New Jersey.

3. Combine these previous steps into a comprehensive compilation for use in preparing impact assessments of the development of offshore energy resources.

4. Define the gaps and deficiencies that exist in the present information baseline as preliminary to conducting new research field surveys.

A secondary set of objectives which altered the scope of work was added just prior to contract negotiation. This addition was requested to meet the requirements of the Council on Environmental Quality (CEQ), which included:

5. Provide general biological habitat descriptions for the two biogeographical regions, including key species for each one.

6. Map the areal extent of these habitats.

7. Provide specific lists of life history data for all key species.

Summary:

The study is a compilation of literature pertaining to the North Atlantic region, between New Jersey and Canada. Specific topics include environmental issues; geological, physical, and chemical oceanography; meteorology; hydrology; systems ecology (phytoplankton, zooplankton, benthic invertebrates, macrophytes, fishes, birds, mammals); unique and endangered environments; environmental quality; and socio-economic topics including demography, recreation, transportation, fisheries, and canal and water use. The following is a list of data gaps and data needs identified in the study:

- more complete and sophisticated geophysical data
- physical controls upon shelf processes
- sediment movement and man's impact on sediment movement
- geologic processes of small beaches and larger strands
- oil pollution of beaches
- flushing rates for estuaries
- measurement of temperature, salinity, and currents
- nutrient concentrations
- suspended matter data
- trace metal and hydrocarbon fates and concentrations
- offshore continuous meteorological observations
- phytoplankton dynamics
- zooplankton abundance and distribution
- benthic invertebrate abundance and distribution
- fish zoogeography, reproduction, feeding, and life history
- baseline bird population studies
- marine mammal abundance and distribution.

Final Report:

A socio-economic and environmental inventory of the North Atlantic region from Sandy Hook, New Jersey to the Bay of Fundy. (TRIGOM; 1974).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Final Report (Vol. I, 5 Bks, Environmental Inventory)
Final Report (Vol II, Socio-Economic Inventory)
Appendices (Vol. III, 2 Bks.)

BLM CONTRACT NO.: **CT6-25 & CT6-26 (continuation)**

Title: Socio-Economic Model Run

Date: April 1976 - September 1976

Cost: $26,120

Prime Contractor:
International Research and Technology Corporation (IRT)
McLean, Virginia 22102

Key Words:
model, socio-economic; oil and gas resources; effects-ecological

Objectives:
The objective of these studies was to determine the onshore environmental impacts of changes in economic activity resulting from offshore oil development on the New England coast, and in the Mid-Atlantic.

Summary:
New England air pollution emissions are expected to increase as a result of industrial and consumer activity related to the development of offshore oil and gas in New England. These increases are projected to present a serious air emissions problem for Union, New Jersey, and Middlesex, New Jersey for one of the scenarios analyzed. These increases can be traced almost entirely to the added refinery activity which results from the processing of New England oil. SO_x emission from natural gas processing plants could present a serious environmental hazard to the New England counties analyzed if stringent controls are not required. With stringent controls, the SO_x emissions increases are tolerable. No other increases in air pollution for the counties analyzed are significant.

Onshore pollution increases resulting from oil and gas development were determined to be insignificant for all the counties analyzed. Non-point water pollution sources, such as potential run-off from construction, was not analyzed in this report and could be important. Further investigation of non-point water pollution impacts should be pursued.

In the Mid-Atlantic report, an assessment is made of the environmental impact of onshore economic activity resulting from potential offshore oil and gas development from Sale No. 49 (second sale in the Mid-Atlantic). The analysis is based on four hypothetical scenarios for several coastal counties, and the results are based on a county basis. This final report is in a draft form, a final version is unavailable.

Final Report:

Environmental consequences of onshore activity resulting from offshore oil and gas development in New England. (M. Narkus Kramer, A. Watson; 1976).

Environmental consequences of onshore activity resulting from offshore oil and gas development in the Mid-Atlantic. (A. Watson, M. O'Farrell; 1978).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

BLM CONTRACT NO.: AA551-CT8-18

Title: Summary and Analysis of Cultural Resource Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras

Date: 23 May 1978 - December 1979

Cost: $235,555

Prime Contractor:
Harvard College (Peabody Museum, Institute of Conservation Archaeology)
Holyoke Center
1350 Massachusetts Avenue
Cambridge, Massachusetts 02138

Program Manager:
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Principal Participants:
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Randal Moir
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Contracting Officer:
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Francis F. Sullivan

COTR: Arthur J. Horowitz
Philip Thomas

Key Words:
cultural resources; geology-general treatment; historic review

Objectives:
An evaluation of the potential cultural resources on the submerged federally controlled lands of the North and Mid-Atlantic Outer Continental Shelf (OCS) is necessary as a rational framework on which to base management decisions concerning OCS development. The objectives of this study were to:

1. Review late Quaternary geology of the areas as it relates to cultural resources.

2. Assess and identify those cultural resources located to date.

3. Determine the probabilities of resource occurrence by area and/or feature.

4. Identify potential pilot study area(s).
5. Review present study techniques and recommend possible modification of search and recovery techniques.
6. Identify significant data gaps.

Summary:
The study area included waters south of the U.S.-Canadian border (at the southern end of the Bay of Fundy) to Cape Hatteras, North Carolina and seaward to the continental shelf edge (200 m). Study of the physical environment involved a literature review of transgressional geological processes and descriptions of the existence and geological history of major shelf features and areas affected by erosional processes resulting from sea level rise.

Models of human settlement on the continental shelf were derived by two methods. First, data were assembled on archaeological sites known from areas contiguous to the project area which have not been inundated by rising sea levels. Using these data, patterns of settlement were derived for different periods, site types, and portions of the project area. These patterns, it is argued, can be extended to portions of the project area. Optimal foraging theory, a body of ecological theory concerned with the patterns of subsistence followed by populations in different types of environments, was also applied. Second, using the reconstruction of environment, models of human settlement in different zones were developed. These two models were combined to form a final model of settlement pattern believed to be the best approximation possible. The final model discussed expected site type, location, size, frequency, and special characteristics and has been translated into graphic form on maps. In buried river valleys close to 100 per cent preservation is expected, while on the valley slopes closer to 40 per cent preservation is expected.

An inventory of approximately 2,000 wrecked ships was compiled in the course of developing models for the distribution of wrecked historic shipping. The analysis of the history of shipping, population growth, and published sources of wreck location, made it possible to predict the locations of wrecked ships of various time periods. The predictions were derived from the integration of information on known shipping lanes, expected number of ships of any one period, hazards to navigation, and other elements. As a result of this analysis, it was determined that the 5-fathom and 10-fathom depths are critical boundaries for predicting historic shipping wreck sites. In this context, ships from the pre-1880 era can be expected to cluster within the 5-fathom line while ships earlier than 1945 can be expected to be distributed inside the 10-fathom line. Vessel remains were also expected to cluster near and in major harbors of the time, such as Boston, New York, Philadelphia, and Hampton and in shallow-water areas near major sea lanes such as Nantucket Shoals, Cape Cod, and Cape Hatteras.

Final Report:

A summary and analysis of cultural resource information on the continental shelf from the Bay of Fundy to Cape Hatteras. (R. Moir, R. Barber, B. Bourque, M.E. Roberts; 1979).

Availability:

Available from NTIS:

Set - PB80-220106
Final Report (Vol. I, Physical Environment) - PB80-220114
Final Report (Vol. II, Archaeology & Paleontology) - PB80-220122
Final Report (Vol. III, Historic Shipping)- PB80-220130
Final Report (Vol. IV, Management) - PB80-220148

BLM CONTRACT NO.: AA851-CT0-75
MMS CONTRACT NO.: 14-12-0001-29181

Title: North Atlantic OCS Area Study of the Economic Cost from Oil Spills to Commercial Fishing

Date: 30 September 1980 - September 1982

Cost: $954,068

Prime Contractor:
University of Rhode Island (URI)
Kingston, Rhode Island 02881

Subcontractors/Cooperating Institutions:
Applied Science Associates, Inc. (ASA)

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Mark Reed (ASA)

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Key Words:
oil spill-effects; model, oil spill; fisheries-commercial; ichthyoplankton; transport (physical process); cod; herring; Georges Bank study

Objectives:
This study was to utilize and further develop the ASA/URI Oil Spill-Fishery Impact Assessment Model System composed of model components for hydrodynamics, oil spill fate, ichthyoplankton transport and fate, and fishery dynamics to address the following objectives:

1. Quantify the impacts of oil spills on selected candidate fish populations in the North Atlantic.
2. Evaluate the subsequent economic loss from oil spills.

3. Evaluate the precision and sensitivity of the prediction method.

4. Include additional model runs for evaluation of oil spill trajectories for the Department of State.

Summary:
An oil spill fishery impact assessment model was developed and composed of integrated subroutines which simulate shelf hydrodynamics, oil spill fates, ichthyoplankton transport and fates, and fishery population dynamics. A three-dimensional hydrodynamic sub-model predicts the tidal, wind, and density forcing. Data input obtained from oceanic drifter data are estimates of monthly net transports arising from tidal, meteorological, density gradient, and pressure forcing. A fishery sub-model predicts variability in year-class strength and age structure in fish stocks using stochastic versions of a nonlinear Leslie Matrix.

Validation was accomplished using available catch data for Atlantic cod, Atlantic herring, haddock, and yellowtail flounder. Spatial and temporal spawning patterns (including egg production) were also input. An ichthyoplankton transport and fates sub-model predicts dispersion and advection of fish eggs and larvae using a random walk procedure. Ichthyoplankton are eliminated as they are impacted by surface and subsurface oil concentrations exceeding a predefined (threshold) value. Data input to the hydrodynamics and fishery sub-models are also used with the ichthyoplankton sub-model.

An oil spill fates sub-model predicts spreading, drifting, evaporation, entrainment, subsurface transport, sinking, and treatment effects. A three-dimensional convective diffusion equation was used to simulate subsurface transport of dispersed oil. Output is governed by a conservation of mass concept: the sum of hydrocarbons on the water surface, in the water, and in the air at a given time must equal the total mass of oil released up to that time, minus any lost through open boundaries of the oil spill fates sub-model. Entrainment, dissolution, and breaking wave characteristics were also included. Spatial and temporal distributions of wind speed and direction, air and water temperature, and spill parameters of oil type, amount, rate, and start time were input to the oil spill fates sub-model.

Interaction among the sub-models provides an oil spill impact analysis on selected fish populations. The model was tested in a deterministic hindcast mode by comparing modeled predictions with observed data from the Ixtoc I oil spill. This model was subsequently updated to include probabilistic and stochastic assessments of catch losses, and effects of multiple aperiodic spills.

A complex interaction exists among spill location and timing, the spatial and temporal spawning distribution of the fishes, and the hydrodynamics of the region. Uncertainty in pre-recruit mortality estimation was the most important factor affecting model estimated impacts. Accurate hydrographic data are essential for reliable simulation of oil and ichthyoplankton dispersion and advection. For the Georges Bank region, impact predictions showed distinct seasonal variability. Largest simulated impacts predicted were for spring and winter spills and for cod and haddock. These predictions suggest that exact spill timing is an important factor in evaluating potential spill impacts. Comparisons between hindcast model runs and observed data for the Ixtoc I spill were generally in agreement.

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Availability:

Available from NTIS:

Final Report - PB83-149104

Other Publications/Reports:

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North Atlantic

Geology and Chemistry

BLM INTERAGENCY AGREEMENT NO.: AA550-MU6-29

Title: North Atlantic Geological Studies, Year 1

Date: 13 October 1976 - 19 May 1980

Cost: $1,896,475

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Energy Resources Company, Inc. (ERCO)
Raytheon Company (RC)
National Oceanic and Atmospheric Administration (NOAA)
EG&G Environmental Consultants (EGG)
Woods Hole Oceanographic Institution (WHOI)

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COTR: Eiji Imamura

Key Words:
hazards-geologic sediment characteristics; trace metals; sediments(geology); transport-sediments; Georges Bank study

Objectives:

1. Measure the rate of sediment mobility over the seabed and monitor resultant changes in bottom morphology and texture.

2. Determine the concentration, distribution, and flux of suspended particulate matter in the water column.

3. Determine the vertical distribution of trace metals in the near-surface sediment at selected locations.

4. Evaluate potential hazards to oil and gas development due to surficial and intermediate depth structure and mass sediment transport events.

5. Support the activities of the prime physical oceanography and chemical/biological benchmark contractors by obtaining supplemental physical oceanographic data by analyzing samples of suspended sediment, and by helping to synthesize and interpret the geological data on physical, biological, or chemical shelf processes.

Summary:
Shelf and slope waters off New England show both the highest and lowest seston concentrations off the eastern United States. The highest concentrations (15,000 ug/l) were measured on the shelf south of Nantucket Island during the winter; this is significant because it exceeds the estimated level of suspended material which may cause crude oil to sink to the bottom. The lowest values were found in slope waters at the shelf edge at concentrations of 50 ug/l. The sources of suspended matter are predominately from biological production and to a lesser extent from resuspension of bottom sediment. The relative importance of the two sources varies with seasonal changes in the biological cycle and stability of the water column and with major storms. Increases in lithogenic material were observed during the winter as a result of the decrease in stability and consequent increase in mixing. Two areas of continuously active sediment resuspension were observed in this study: one area in the southwest part of the Gulf of Maine north of the Great South Channel and the second south of Nantucket Island.

Site analysis of vibracores collected from the North Atlantic Outer Continental Shelf (OCS) areas indicates a predominance of the sand size class at essentially all depths and at all locations. Larger concentrations of silts and clays were evident in samples taken west of the Great South Channel, and more occurrences of gravel were observed to the east. Texture and age suggest that the sediments are Late Wisconsian glacial till. There is a uniform texture to a depth of 20-30 cm; possibly due to effective mixing of the sediments to this depth. The major clay mineral group observed was illite with moderate amounts of chlorite and small amounts of kaolinite; the illite and chlorite are indicative of largely unweathered material that was eroded in Paleozoic and older rocks in the northern Appalachian region. The leachable concentrations of Cr, Cu, and Zn and the total concentrations of Ba, Cd, Cr, Cu, Fe, Ni, Pb, V, and Zn are low and characteristic of an area having uncontaminated coarse-grained sediment. Radiocarbon analyses of organic sediment south of Nantucket Island and east of the "mud patch" center indicate a fairly constant accumulation of fine-grained sediment at an average rate of 36 to 58 cm/1,000 years during the past 10,000 years.

The maximum current speeds and associated bottom sediment movement took place in waters less than 50 m deep on the top of Georges Bank and in the Great South Channel which serves as a conduit for flow from the Gulf of Maine. In these areas stability problems due to scour will be greatest, and excavation problems, where large lag gravel and boulder deposits occur, will be most difficult. Any pollutants introduced into these areas can be distributed rapidly over large distances by the high current speeds and mixed into the mobile substrate. Thus, the rich organic benthic and epibenthic life could be affected over a wide area in a short period of time. Conversely, the widespread mixing of the water column and the sediment movement could also dilute pollutants rapidly, perhaps to levels that would not affect organisms seriously. These problems can only be resolved over a period of time with detailed future observations.

Several potential hazards were identified. Sediment mobility on Georges Bank suggests two kinds of potential hazards: scour around structures and deposition of excessive sediment around supporting structures. The shallow sediments are quite variable; this could lead to differential settling. No shallow faults or slumps were detected in this area of the slope.

Final Report:

Environmental geologic studies in the Georges Bank area, United States northeastern Atlantic Outer Continental Shelf, 1975-1977. U.S. Geological Survey Open-File Report 80-240. (J.M. Aaron, ed.; 1980).

Availability:

Available from NTIS:
Final Report - PB80-177512
Executive Summary - PB80-177520

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Other Related Contracts Within This Study Program:

- MU0-16/29175
- MU0-18/29175
- IA1-15/29183
- IA1-17/29184
- IA2-26/29196
- CT5-42/MU5-3
- CT6-62/MU7-31
- MU6-56
- MU8-13
- MU8-21
- MU8-24
- MU9-04
- MU9-08/29166

BLM INTERAGENCY AGREEMENT NO.: AA551-MU8-24

Title: North Atlantic Geological Studies, Year 2

Date: 6 July 1978 - 15 May 1979

Cost: $999,782

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
NOVA University (NOVAU)
Woods Hole Oceanographic Institution (WHOI)
University of Rhode Island (URI)

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Contracting Officer:
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COTR: Eiji Imamura

Key Words:
Georges Bank study; sediments (geology); hazards-geologic sediment characteristics; transport (physical processes); transport-sediments; circulation/current study

Objectives:

1. Measure or estimate the rate of sediment mobility over the seabed and monitor the resultant changes in bottom morphology and texture.

2. Assess the seasonal and spatial variability of the major sediment transport mechanisms and characterize the regional bottom circulation patterns.

3. Determine the concentration, distribution, and flux of suspended particulate matter in the water column.

4. Identify and map mass-movement features and investigate the ages, causes, mechanisms, and potential for reactivation or extension.

5. Identify potentially disruptive features in the shallow subsurface section, including faults and bodies of unstable sediment, and assess the potential for failure under natural or engineered stress.

6. Assess geotechnical properties of near-surface sediment in selected tracts.

7. Support the activities of the physical oceanography contractor by obtaining supplemental information and helping to synthesize and interpret data as it pertains to physical oceanographic processes on the shelf.

Summary:

This study presents the results of research undertaken by the USGS in pursuit of objectives outlined in Memoranda of Understanding (MOU) AA55-MU8-24 and AA551-MU9-04, and also in continuation of those objectives addressed by MOU AA550-MU6-29. The research deals mainly with oceanographic processes and surficial geological conditions on the Outer Continental Shelf (OCS) and continental slope of the North Atlantic region (i.e., Georges Bank and vicinity), specifically in the Lease Sale No. 52 lease area. The study presents data acquired from 16 cruises between 1977 and 1979 as well as the results of the long-term tripod and current meter program begun in 1975 to study sediment transport. The study also includes descriptions of methods, procedures instrumentation, and analytical results. The analytical results and the cruise reports for each of the sampling and seismic cruises are tabulated in appendices. Original data, including seismic records and trackline charts, are on file with the USGS in Woods Hole, Massachusetts.

A clockwise circulation around Georges Bank was measured by means of moored current meters, aircraft-tracked surface drifters, and satellite-tracked drifters drogued at 10 m. The strongest flow was in a narrow jetlike current (30 cm/s) along the northern flank of the Bank. The flow of shelf water on the southern flank was westward (10 cm/s) toward the Middle Atlantic Bight; some of this water flowed northward through the eastern side of Great South Channel and recirculated around Georges Bank. The satellite-tracked drifters and the moored observations indicate that the circulation around the Bank was not completely closed and considerable variability occurs in the trajectory of an individual water particle.

Nearly continuous current measurements at 45 and 75 m were made from May 1975 to March 1979 at 40°51'N, 67°24'W on the southern flank of Georges Bank in water 85 m deep. Hydrographic observations suggest that all of the mean shear and all of the seasonal variation between 45 and 75 m can be attributed to the seasonal change in the cross-bank density field. The current observations on the southern flank and additional measurements made at other locations around the perimeter of the Bank suggest that although a subsurface clockwise circulation around the Bank exists throughout the year, the flow was strongest in late summer and early fall and that recirculation around

Georges Bank may be most likely in late summer. The flow was weakest and most variable in winter.

Strong correlations were observed among subtidal longshelf currents from the Middle Atlantic Bight (MAB) to the Georges Bank region, a distance spanning 615 km. The longshelf current consisted predominantly of wind-forced motions and free waves, which together accounted for 75-90 per cent of the longshelf current energy. Much stronger longshelf currents were observed in the MAB than on Georges Bank. The MAB/Georges Bank energy ratio for wind-forced currents on the 60 m isobath was 20. Surface and bottom stresses, the longshelf pressure gradient, and Coriolis force on the cross-shelf flow were important terms in the longshelf momentum balance. An analytic model of wind-forced current, which incorporated the significant force balances, accounted for the longshelf variation in wind-forced currents.

Observations of the semidiurnal (M_2) tidal current, bottom pressure, and coastal sea level from Nova Scotia to Cape May, New Jersey show that: 1) the surface pressure at the edge of the Continental Shelf in the study area has a relatively uniform amplitude (40 cm) and phase (12 hr Greenwich); 2) in the Mid-Atlantic Bight, the semidiurnal M_2 tide is co-oscillating, and the onshore M_2 tidal current reaches a maximum approximately 90° or 3.1 hr before high water; 3) in the Georges Bank region of the shelf, the M_2 tide is more progressive than it is in the Mid-Atlantic Bight, and the onshore M_2 tidal current in the Georges Bank region of the shelf reaches a maximum about 7 or 14 min before high water; 4) the strongest M_2 tidal currents observed in the study area are near the crest of Georges Bank (typical amplitudes are 74 cm/s near the surface); 5) the M_2 tidal currents are weaker in the Mid-Atlantic Bight (typical amplitudes are 16 cm/s near the surface) than on Georges Bank; and 6) the tidal currents are weakest near the bottom south of Cape Cod in a region of transition between progressive and co-oscillating tides.

The highest concentrations of suspended matter in bottom waters on the continental shelf occur between Georges Bank and the Middle Atlantic states over the area of fine-grained sediments south of Martha's Vineyard known as the Mud Patch. Active resuspension of bottom sediments appears to take place under the influence of tidal currents, perhaps aided by the activity of bottom fauna. The distribution of turbidity maxima with depth remained generally constant over the 24-hour sampling period. A significant effect of rapidly recycled particulates in the water column is the enhanced opportunity for absorption of dissolved pollutants. During winter, this process may be important over much of the shelf and throughout the water column due to the lack of water-column stability and because of extensive vertical mixing of resuspended sediments.

An area of fine-grained sediment approximately 170 km x 74 km in size, located in water depths between 60 m and 150 m south of Martha's Vineyard, Massachusetts, is a site of modern sediment deposition. The high accumulation rates, ^{210}Pb inventories, and trace-metal profiles imply that this area is a modern sink for fine-grained sediments and for pollutants associated with particulate matter in the water column. This is the only site of present-day natural deposition on the continental shelf off the eastern United States, exclusive of the Gulf of Maine. Because the net currents on the outer half of this continental shelf flow from northeast to southwest, this fine-grained deposit may receive its sediments and possible contaminants from the Nantucket Shoals and Georges Bank regions.

Four bed-form provinces have been identified on Georges Bank using sidescan-sonar and echo-sounding techniques: large sand waves superimposed on sand ridges, small sand waves, megaripples, and featureless sea floor. The large sand waves and sand ripples are found on the Bank crest where the surface tidal currents are strongest. Areas of small sand waves and megaripples, formed where tidal currents are moderate in strength, border the area of large sand waves to the north and south. Featureless sea floor is found farthest from the Bank crest where surface tidal currents are weakest.

Seismic-refection profiles show that the fine-grained deposit, which is as much as 13 m thick, has accumulated during the last transgression because it rests on a reflector that is geomorphically similar to and continuous with the Holocene transgressive sand sheet still exposed on the shelf to the west. The ridge and swale topography comprising the sand sheet on the shelf off New Jersey and Long Island are relict in origin as these same features are found buried under the fine sediment deposit. Southwestward migrating megaripples observed on the sonagraphs in the eastern part of the deposit are evidence that sediment is still actively accumulating in this area. In the western part of the deposit, where surface sediment is composed of silt plus clay, evidence of present sediment mobility consists of changes in the near-bottom suspended-matter concentrations primarily associated with storms. Nantucket Shoals and Georges Bank are thought to be the sources for the fine-textured sediment.

The surficial sediments on the continental slope off Georges Bank tend to be highly plastic, inorganic silts and clays. Measurements of shear strength and index properties, and inferences concerning consolidation state suggest that the sites of two cores were once buried under a considerable amount of overburden. They may be mass-movement scars. Slope stability analyses and indirect assessments of consolidation states suggest that the surficial sediments cored are stable with respect to mass movement.

Final Report:

Environmental geologic studies in the Georges Bank Area, United States northeastern Atlantic continental margin, 1978-1979. (D.W. O'Leary, ed.; 1982).

Availability:

Available from NTIS:

Final Report and Executive Summary - PB83-144808

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Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31
MU6-29
MU6-56
MU8-13
MU8-21
MU9-04

North Atlantic

Physical Oceanography

MU9-08/29166 BLM CONTRACT NO. AA550-CT6-50

Title: EG&G New England Physical Oceanography, Year 1

Date: 9 September 1976 - 31 August 1979

Cost: $1,416,804

Prime Contractor:
EG&G International, Inc. (EGG)
Environmental Consultants Division
300 Bear Hill Road
Waltham, Massachusetts 02154

Subcontractors/Cooperating Institutions:
Raytheon
University of Delaware (UD)
University of Rhode Island (URI)
John A. Vernersch

Chartered Research Vessels:
R/V Atlantic Twin
Whitefoot Tug
R/V Sub Sig II

Program Manager:
Richard Scarlet

Principal Participants:
David O. Cook
C. Flagg
Daniel E. Frye
Bruce Magnell
Christopher N.K. Mooers (UD)

Contracting Officer:
Anthony F. Guida
Jeffrey P. Petrino

COTR: Kenneth J. Berger

Key Words:
Georges Bank study; circulation/current study; hydrographic, salinity, temperature data

Final Report:
The data from this contract have been interpreted and synthesized in the final report of Contract No. AA851-CT1-39.

Other Related Contracts Within This Study Program:

CT1-39/29188	CT8-46
CT6-53	CT8-47

BLM CONTRACT NO.: AA851-CT6-53/29159

Title: Raytheon New England Physical Oceanography, Year 1

Date: 21 September 1976 - Incomplete

Cost: $3,812,767

Prime Contractor:

Raytheon Company
P.O. BOX 360
Portsmouth, Rhode Island 02871

Key Words:

Georges Bank study; circulation/current study; hydrographic, salinity, temperature data

Final Report:

The data from this study have been interpreted and synthesized in the final report of Contract No. AA851-CT1-39.

Other Related Contracts Within This Study Program:

CT1-39/29188
CT6-50
CT8-46
CT8-47

BLM CONTRACT NO.: AA551-CT8-46

Title: EG&G New England Physical Oceanography Study, Year 2

Date: September 1978 - June 1980

Cost: $2,122,850

Prime Contractor:

EG&G International, Inc. (EGG)
Environmental Consultants Division
300 Bear Hill Road
Waltham, Massachusetts 02154

Key Words:

Georges Bank study; circulation/current study; hydrographic, salinity, temperature data

Final Report:

The data from this contract have been interpreted and synthesized in the final report of Contract No. AA851-CT1-39.

Other Related Contracts Within This Study Program:

CT1-39/29188
CT6-50
CT6-53
CT8-47

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BLM CONTRACT NO.: **AA551-CT8-47/29162**

Title: Raytheon New England Physical Oceanography, Year 2

Date: 28 September 1978 - Incomplete

Cost: $696,990

Prime Contractor:
Raytheon Company
P.O. BOX 360
Portsmouth, Rhode Island 02871

Key Words:
Georges Bank study; circulation/current study; hydrographic, salinity, temperature data

Final Report:
The data from this study have been interpreted and synthesized in the final report of Contract No. AA851-CT1-39.

Other Related Contracts Within This Study Program:
- CT1-39/29188
- CT6-50
- CT6-53
- CT8-46/29163

BLM CONTRACT NO.: AA851-CT1-39
MMS CONTRACT NO.: 14-12-0001-29188

Title: Interpretation of Physical Oceanographic Conditions and their Applications to Pollutant Transfer in the North Atlantic U.S. Outer Continental Shelf

Date: 27 April 1981 - 13 August 1982

Cost: $824,414

Prime Contractor:
EG&G International, Inc. (EGG)
Environmental Consultants Division
300 Bear Hill Road
Waltham, Massachusetts 02154

Subcontractors/Cooperating Institutions:
Applied Sciences Associates (ASA)
Associated Scientists of Woods Hole (ASWH)
University of Delaware (UD)
University of New Hampshire (UNH)

Program Manager:
Richard I. Scarlet

Principal Participants:
Wendell S. Brown (UNH)
Jerome J. Cura, Jr.
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Daniel E. Frye
Richard Garvine (UD)
George R. Halliwell, Jr. (UD)
James D. Irish (UNH)
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Charles A. Menzie
Charles N.M. Mooers (UD)
Neal Pettigrew (UNH)
Malcolm L. Spaulding (ASA)
Craig Swanson (ASA)
W. Redwood Wright (ASWH)

Contracting Officer:
Jeffrey P. Petrino

COTR: William H. Lang

Key Words:
hydrographic, salinity, temperature data; circulation/current study; oil transport; transport (physical process); model, physical sciences; Georges Bank study

Objectives:
The sole purpose of this study was to synthesize and interpret physical oceanographic data collected for the BLM (now MMS) by Raytheon (CT6-53, CT8-47), EG&G (CT6-50, CT8-46), and when appropriate, USGS (MU6-29, MU8-24, MU9-4, and MU0-18). The above data will be interpreted in light of the following objectives.

1. Develop and refine concepts of the transport, dilution, and dispersion processes acting on the New England Outer Continental Shelf (OCS).
2. Qualify and quantify the various transport processes such that the fate of OCS oil and gas related discharges released on Georges Bank can be described.
3. Develop a conceptual model of the mean circulation on Georges Bank with a quantitative description of the variability of the circulation and the exchange rates which dominate the movement of pollutants and nutrients.
4. Identify source regions for nutrients, geographic areas of high productivity, and to establish residence times on Georges Bank.

Summary:
This analysis includes hydrographic fields (temperatures, salinities, densities, and nutrients), currents measured by moored current meters and drogues, productivity and plankton assemblages, and meteorological forcing fields. The report presents and describes the determination of average values and seasonal cycles of these properties. Interpretations of mixing and exchange rates, residence times, nutrient sources, and water mass formation are presented. Dynamics of the currents, and their relation to winds, storms, tides, and density fields are analyzed, and numerical model simulations of wind-driven currents are compared with observations. Features studied in particular detail include the Georges Bank gyre circulation, the cold band, the influence of Gulf Stream eddies on the shelf/slope front, and factors associated with enhanced biological productivity.

The physical oceanography of Georges Bank is characterized by the presence of a gyre whose currents move in a clockwise direction. Seasonal differences in the current speed and gyre were noted. Detailed seasonal and annual average maps of current structure and hydrography in and around Georges Bank were presented. Residence time for water on Georges Bank, based on drogue and current meter measurements, was consistent with the box model flow for the New England OCS, and ranged from 40 to 80 days. Drogue residence time in summer was 66 days versus 45 days in winter. The difference was attributed to increased closure of the gyre circulation in summer.

The Georges Bank gyre consists of clockwise currents flowing around the Bank. The gyre is more intense and closed in summer than in winter. A closed gyre suggests that contaminants in the water column could be trapped around the bank.

In winter, a narrow current (about 20 km wide), called a jet, flows eastward along the north margin of the bank at approximately the 80 m isobath. The jet originates in an area north and east of Great South Channel and derives its initial water from the Wilkinson Basin. Currents in this jet average 18 cm s^{-1} near the surface and 7 cm s^{-1}

at 80 m depth. Along the bank's south side, this current averages 12 cm s^{-1} on the surface and 3 cm s^{-1} in 85 m of water. Only 25 per cent of the flow recirculates into the Great South Channel and rejoins the northern jet.

In summer, currents in the gyre increase in speed starting on the north side (42 cm s^{-1} at surface; 21 cm s^{-1} at 80 m). The proportion of westward-flowing water along the south of the bank that turns north through the channel increases, reaching a maximum of 65 per cent during late July. The Gulf of Maine and the waters of Georges Bank are thermally stratified due to summer heating and the surface water has become distinct from the intermediate depth water.

For construction of the box model, transports were calculated through vertical sections around Georges Bank, past Cape Sable-Browns Bank, through the Nantucket Flux array, and through the Northeast Channel. Results indicated a shelf water system driven by two major inputs: (1) water from the Scotian Shelf (52%) and (2) water from the Northeast Channel (43%). Outflow was primarily along the shelf south of Cape Cod (48%) and water displacement offshore by the shelf/slope front eddies (37%). The annual mass flux rate was 748 x 103 m^3 s^{-1}, representing a flushing time of 280 days for the whole region. In winter, the flushing rate dropped to 256 days, while in summer it rose to 305 days.

Major nutrient sources on Georges Bank are considered to be Gulf of Maine surface water and intermediate water. This study showed a close spatial correlation between measures of mixing history and planktonic species assemblages. Data from New England Outer Continental Shelf Physical Oceanography (NEOCSPO) cruises showed that the "cold band" off Georges Bank is totally replenished every 30 to 60 days. Detailed examination of NEOCSPO data showed four sources for the water in the cold band: (1) the central region of Georges Bank; (2) near surface in the Gulf of Maine; (3) mid-depth along the bank's north flank; and (4) from 100 to 150 m deep in the Northeast Channel. These waters become mixed at the Northeast Peak to form the cold bank. The migration of the deep Northeast Channel water is important because it provides a pathway for nutrient-rich cold deepwater to reach the biological communities of the bank.

Final Report:

Interpretations of the physical oceanography of Georges Bank. (C.N. Flagg, B.A. Magnell, R. Frye, J.J. Cura, S.E. McDowell, R.I. Scarlet; 1982).

Availability:

Available from NTIS:
- Final Report (Vol. I) - PB83-149054
- Appendices (Vol. II) - PB83-149062

Other Publications/Reports:

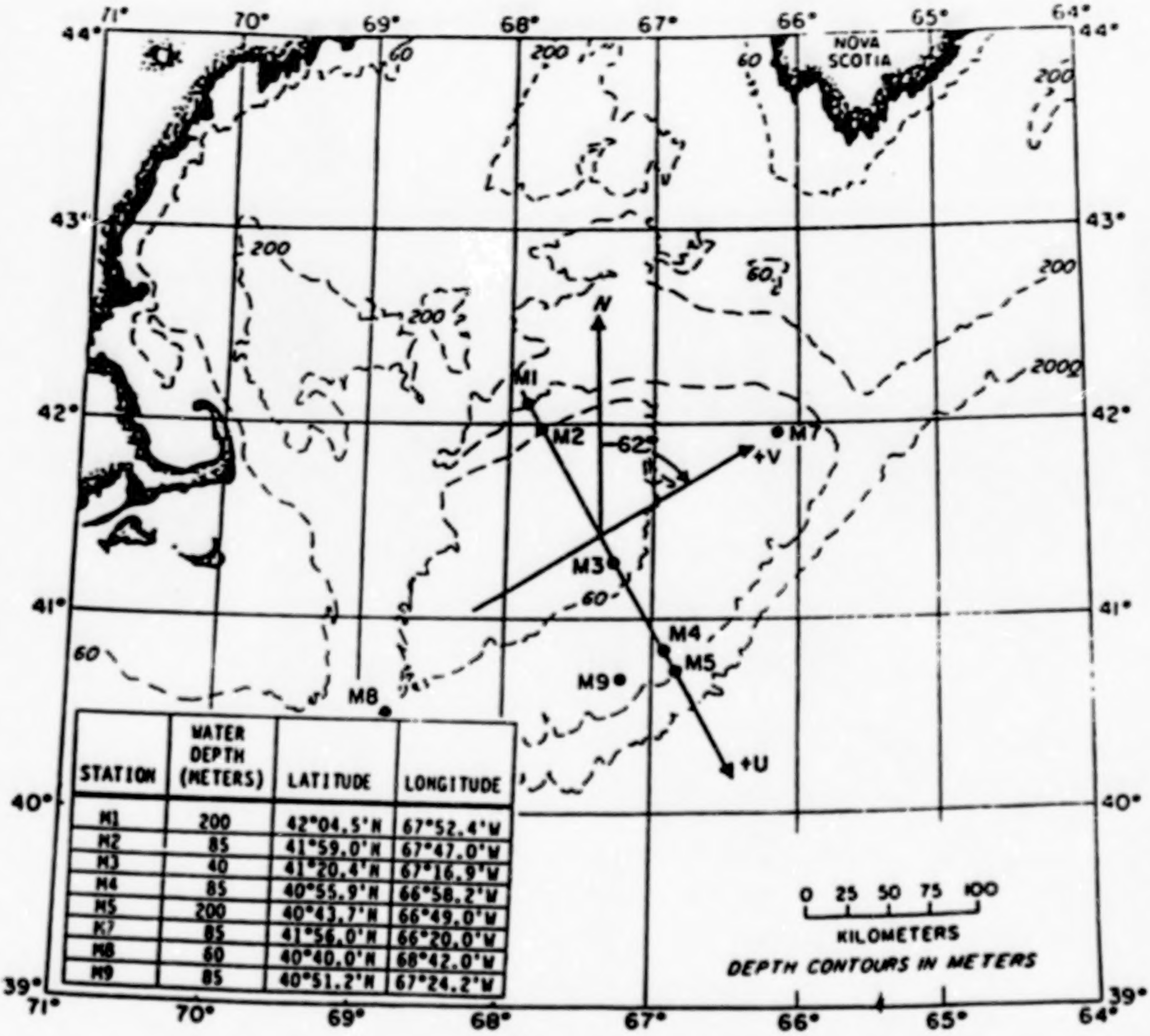
Brown, W.S., 1984. A comparison of Georges Bank, Gulf of Maine and New England shelf tidal dynamics. Journal of Physical Oceanography 14:145-167.

Cura, J.J. and J.H. Ryther. Relationships between phytoplankton distribution and production and the physical oceanography in the Georges Bank region (90 p. manuscript).

Halliwell, G.R., and C.N.K. Mooers. Meanders of the Gulf Stream downstream from Cape Hatteras, through 1978 (50 p. manuscript).

Other Related Contracts Within This Study Program:

CT6-50
CT6-53
CT8-46
CT8-47



STATION	WATER DEPTH (METERS)	LATITUDE	LONGITUDE
M1	200	42°04.5'N	67°52.4'W
M2	85	41°59.0'N	67°47.0'W
M3	40	41°20.4'N	67°16.9'W
M4	85	40°55.9'N	66°58.2'W
M5	200	40°43.7'N	66°49.0'W
M7	85	41°56.0'N	66°20.0'W
M8	60	40°40.0'N	68°42.0'W
M9	85	40°51.2'N	67°24.2'W

Figure 7. Location of moored instrument stations off New England. Data were synthesized under BLM Contract No. AA851-CT1-39. (Source: BLM Contract No. AA851-CT1-39).

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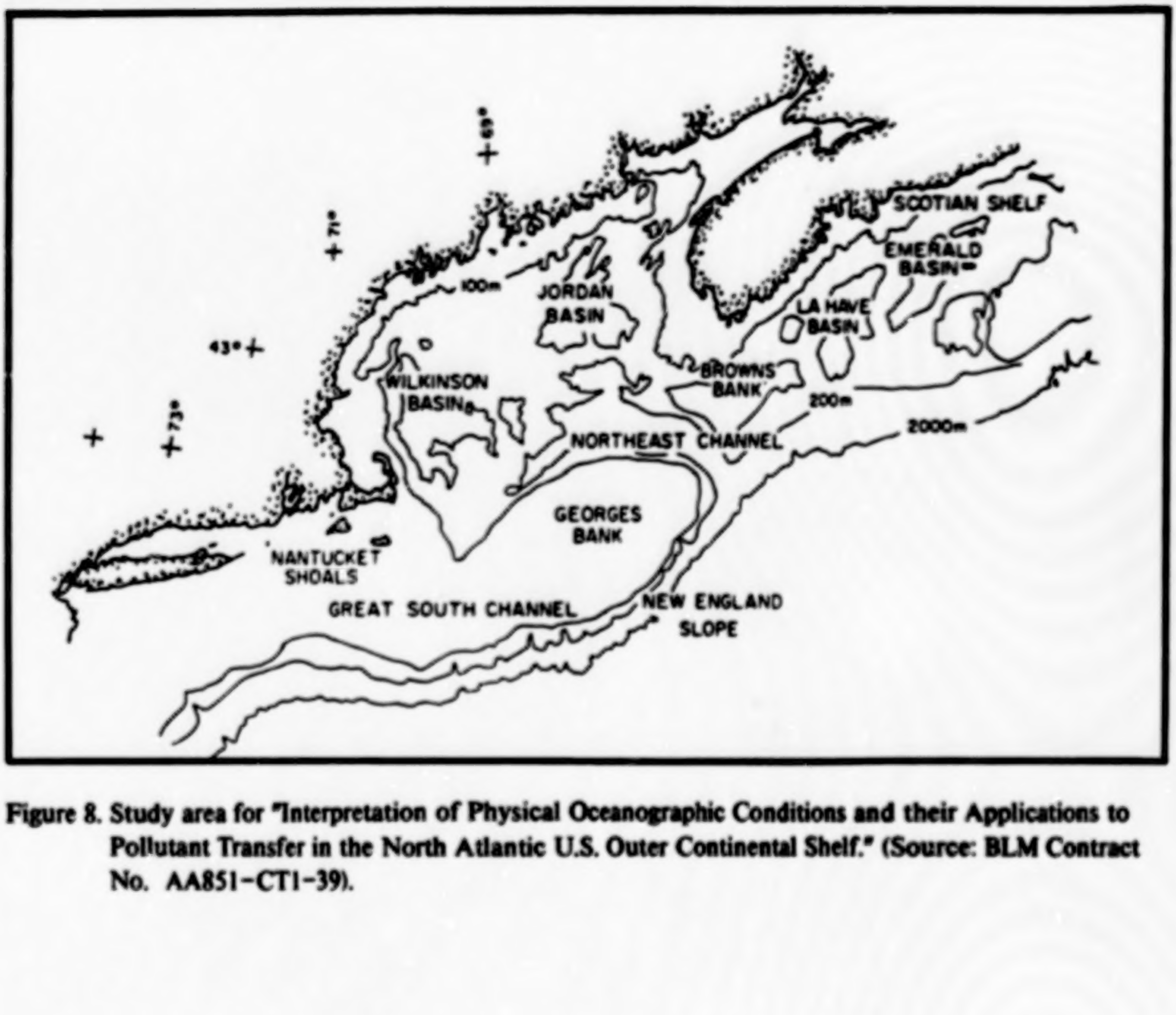

Figure 8. Study area for "Interpretation of Physical Oceanographic Conditions and their Applications to Pollutant Transfer in the North Atlantic U.S. Outer Continental Shelf." (Source: BLM Contract No. AA851-CT1-39).

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BLM CONTRACT NO.: AA551-IA8-14

Title: Georges Bank Climatological and Oceanographic Analysis

Date: March 1978 - September 1979

Cost: $394,847

Prime Contractor:
National Oceanic and Atmospheric Administration (NOAA)
Marine Environmental Assessment Division
Center for Environmental Assessment Services
Washington, D.C. 20036

Program Manager:
Fredric A. Godshall

Principal Participants:
Joseph M. Bishop
Fred Everdale
Steven W. Fehler
Robert G. Williams

Key Words:
hydrographic, salinity, temperature data; circulation/ current study; Georges Bank study; meteorology

Objectives:

1. Use environmental data from the national archives (The National Oceanographic Data Center and National Climatic Center) to produce an oceanographic analysis of the Georges Bank region.

2. Produce climatology and wave analyses to provide information related to ship operations and the surface movement of pollutants.

3. Produce summaries of archived data for the study region.

Summary:
The surface wind field in the study area varies from a northwesterly wind regime in winter to a southwesterly wind regime in summer. The summer wind direction in the southeastern portion of the study region is veered relative to wind in the northwestern part of the region, reflecting the dominance of the Atlantic subtropical anticyclone. In winter intraregional wind direction differences seemed to be associated with sea-air temperature differences. Apparently, the effectiveness of wind-forced surface circulation was about equal to the combined effect of tide and residual (regional scale) circulation. Advection fog was the most frequently occurring restriction to visibility in the study region. Visibility less than 10 nautical miles (nmi) occurred about 70 per cent of the time in the Georges Bank area in spring. North of 42°N (northern half of the

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study region) at least light ship icing may be expected on the order of 1 per cent of the time over 5 months of the year.

Shelf and slope water masses were found within the study region. Because of deep basins and channels in the shelf, highly saline slope waters intruded into the bottom layers of central geographic areas of the study region. With relatively low saline water (from outflow of the Gulf of St. Lawrence and from local rivers) on the surface, high static stability of the water column is common to most of the study region. A cold intermediate-depth layer (with temperature of about 2° to 8°C), found at depths greater than about 75 m, is produced by winter-cooled water overturned and maintained through summer by the general absence of strong vertical mixing. Except in the relatively shallow areas (depths less than 75 m) where well-mixed water usually prevails, vertical mixing and modification of water column structure occurs intermittently. Surface temperatures on Georges Bank and other shallow areas of the region (without consideration of nearshore area) tended to be relatively warm in winter and cool in summer because of vertical mixing. An area of relatively high surface salinity (maximum concentration in November) occurred over the basins in the Gulf of Maine, produced by vertical mixing of relatively saline bottom and mid-depth waters.

By the use of hydrographic summaries and assumption of geostrophy, diagnostic modeling efforts produced seasonal circulation pattern estimates for the study region. These patterns were in agreement with the classical descriptions of general circulation of the region, i.e., a cyclonic gyre in the Gulf of Maine and an anticyclonic gyre over Georges Bank are established in spring. In winter the mid-Gulf of Maine gyre (maintained in subsurface layers) appeared poorly organized at the surface; flow over Georges Bank was from the Gulf of Maine. A net annual cyclonic circulation gyre extends over the Scotian Shelf.

Better understanding of intraregional variations of hydrographic and nutrient variables can be obtained by defining water mass properties and evaluating mixing. In general, mixing is produced by turbulence and small scale circulation features. It was recommended that information about smaller scale circulation features be organized in context of the known characteristics of the broader, regional scale of circulation in order to facilitate the interpretation of the results of the measurement programs for applications at other times and locations.

Final Report:

A climatologic and oceanographic analysis of the Georges Bank Region of the Outer Continental Shelf. (F.A. Godshall, R.G. Williams, J.M. Bishop, F. Everdale, and S.W. Fehler; 1980).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

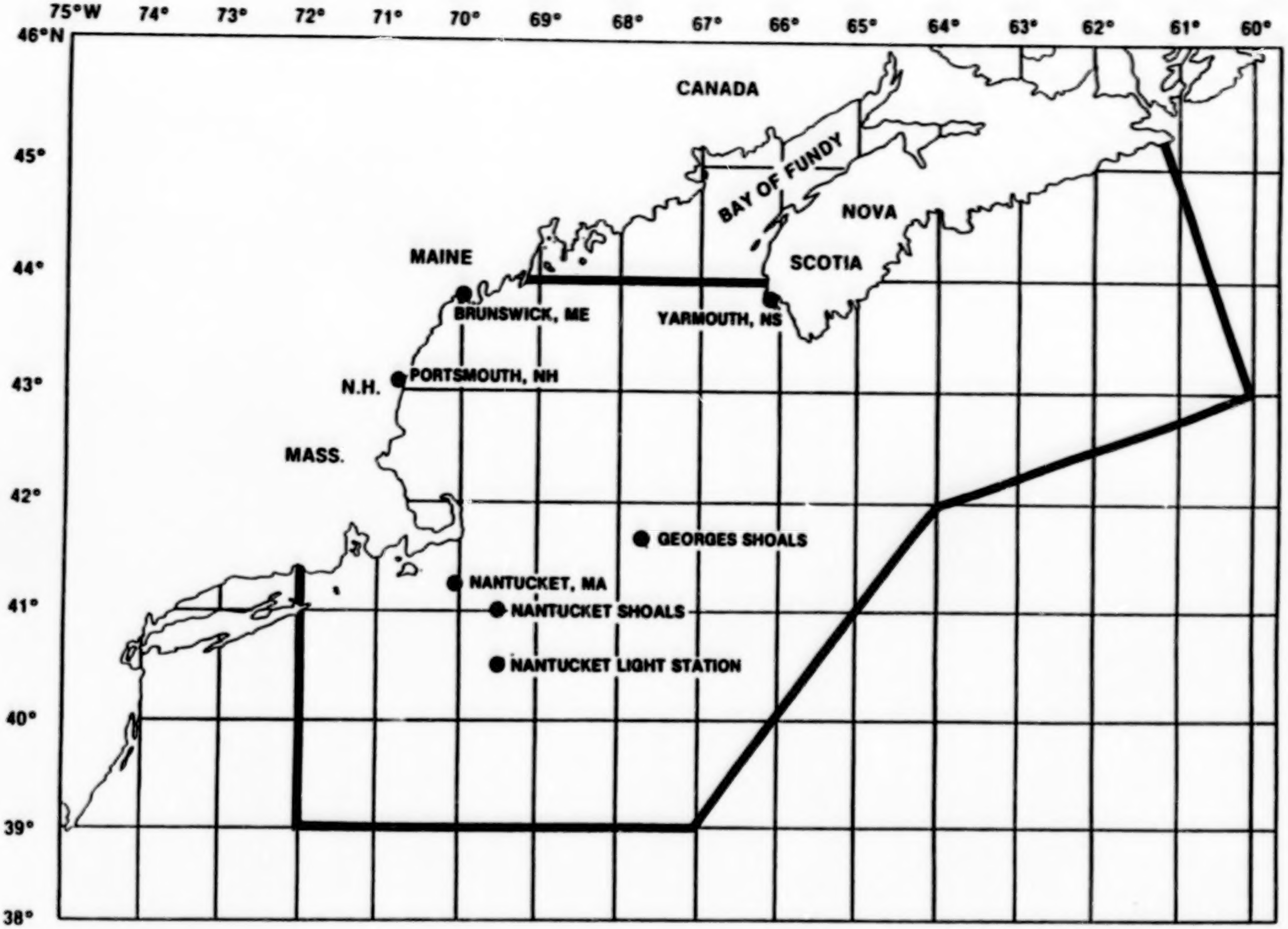

Figure 9. Study area for "Georges Bank Climatological and Oceanographic Analysis." (Source: BLM Contract No. AA551-IA8-14).

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MMS INTERAGENCY AGREEMENT NO. 14-12-0001-30180

Title: North Atlantic Slope and Canyon Study

Date: March 1984 - December 1986

Cost: $873,048

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)
Eliason Data Services (EDS)

Chartered Research Vessels:
R/V Oceanus

Program Manager:
Brad Butman

Principal Participants:
Mike Bothner
John Moody
Skip Little (WHOI)

Contracting Officer:
Jeffrey P. Petrino

COTR: William H. Lang
James Lane

Key Words:
geology, submarine canyons; circulation/current study; hydrographic, salinity, temperature data; transport (physical processes)

Objectives:
This study continued field measurements made by USGS on shelf, slope, and canyon currents in the North Atlantic region. General objectives of the study were to:

1. Complete field measurements at established slope stations in the North Atlantic region and analyze the time-series data with special emphasis on long-term processes and low frequency fluctuations critical to understanding sediment (and pollutant) pathways.

2. Complete interpretation of data from the Canyon Dynamics Experiments and verify (or modify) preliminary results reported in the FY '80-'82 Report (IA No. 29196).

3. Provide a written summary of field results, interpreted in conjunction with complimentary field programs of the Department of Energy, WHOI, and the MMS Mid-Atlantic Slope and Rise Study (MASARS), and provide a concise account of study conclusions, highlighting significance to proposed oil and gas activities in the North Atlantic slope and rise area.

Summary:

The sedimentary and hydrographic regime in the major canyons on the southern flank of Georges Bank are not the same. In the Oceanographer Canyon, the surficial sediments along the axis are coarser than in Lydonia and the currents are stronger. Little fine-grained sediment accumulates in the head of Oceanographer Canyon.

The current flow pattern within the canyon is complex. There is evidence for down-canyon transport near the head in Lydonia, Oceanographer, and Baltimore Canyons and there is up-canyon transport in Lydonia at depths of about 500 m. Additional measurements are needed to fully resolve the spatial variability in the direction of transport along the axis and its importance in determining the accumulation of sediments along the axis floor.

The canyons are not tranquil. The strongest flows occur at semidiurnal tidal periods, but are not always directly coupled to the tide on the shelf. Short duration packets of fluctuations occur in the canyon, some apparently generated by the passage of Gulf Stream warm core rings. Gulf Stream warm core rings strongly affect the flow along the outer edge of the shelf. There is a net eastward flow in excess of 50 cm/s associated with the strongest ring events.

Transport of sediment at the outer edge of the shelf is in the downslope direction. At water depths below 500 m, the currents are rarely strong enough to resuspend the existing sediments and particles reaching the sea floor should remain there.

The measurements made in the Lydonia Canyon Experiment and the Slope Experiment show sediments from the shelf are transported into the head of Lydonia Canyon and accumulate there. These fine-grained sediments are frequently resuspended. Based on elevated inventories of 210Pb and 239, 240Pu, the sediments in Lydonia Canyon scavenge pollutants from the water column. Thus the head of Lydonia Canyon is a sink for fine sediments and a potential sink for pollutants introduced onto the shelf.

The concentration of barium, a major component of drill muds used during exploratory drilling on the south flank of Georges Bank, increased in the head of Lydonia Canyon during the period when exploratory wells were drilled near the canyon on the shelf. This is direct evidence for transport of shelf material into the canyon.

Final Report:

North Atlantic slope and canyon study: Final report. (Butman, B. ed.; 1986).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Available from NTIS:

Vol. I. PB 87-198719/AS
Vol. II. PB 87-198727/AS

Other Publications/Reports:

Aaron, J.M., B. Butman, M.H. Bothner, and R.E. Sylwester. 1980. Maps showing environmental conditions to potential geologic hazards on the United States northeastern Atlantic continental margin. U.S. Geological Survey Miscellaneous Field Studies Map-MF 1193.

Bothner, M.H., B. Butman, C.M. Parmenter. A field comparison of four sediment traps: Changes in collection rate with trap geometry and size. 27 p.

Butman, B., 1988. Downslope Eulerian mean flow associated with high-frequency current fluctuations observed on the Outer Continental Shelf and upper slope along the northeastern United States continental margin: Implications for sediment transport. Continental Shelf Research 8(5-7):811-840.

Butman, B. and J.A. Moody. 1984. A bathymetric map of Lydonia Canyon, U.S. Atlantic Outer Continental Shelf. U.S. Geological Survey Miscellaneous Field Studies Map MF-1710.

Csanady, G.T., J. Churchill, and B. Butman. 1988. Near-bottom currents over the continental slope in the Mid-Atlantic Bight. Continental Shelf Research 8(5-7):653-671. Woods Hole Oceanographic. Contribution No. 6316, 32 p.

Moody, J.A., B. Butman, and M.H. Bothner. Estimates of near-bottom suspended-matter concentration during storms. 38 p.

Noble, M. and B. Butman. 1989. The structure of subtidal currents within and around Lydonia Canyon; evidence for enhanced cross-shelf fluctuations over the mouth of the canyon. Journal of Geophysical Research. In press.

Other Related Contracts Within This Study Program:

IA1-17/29184
IA2-26/29196
30066

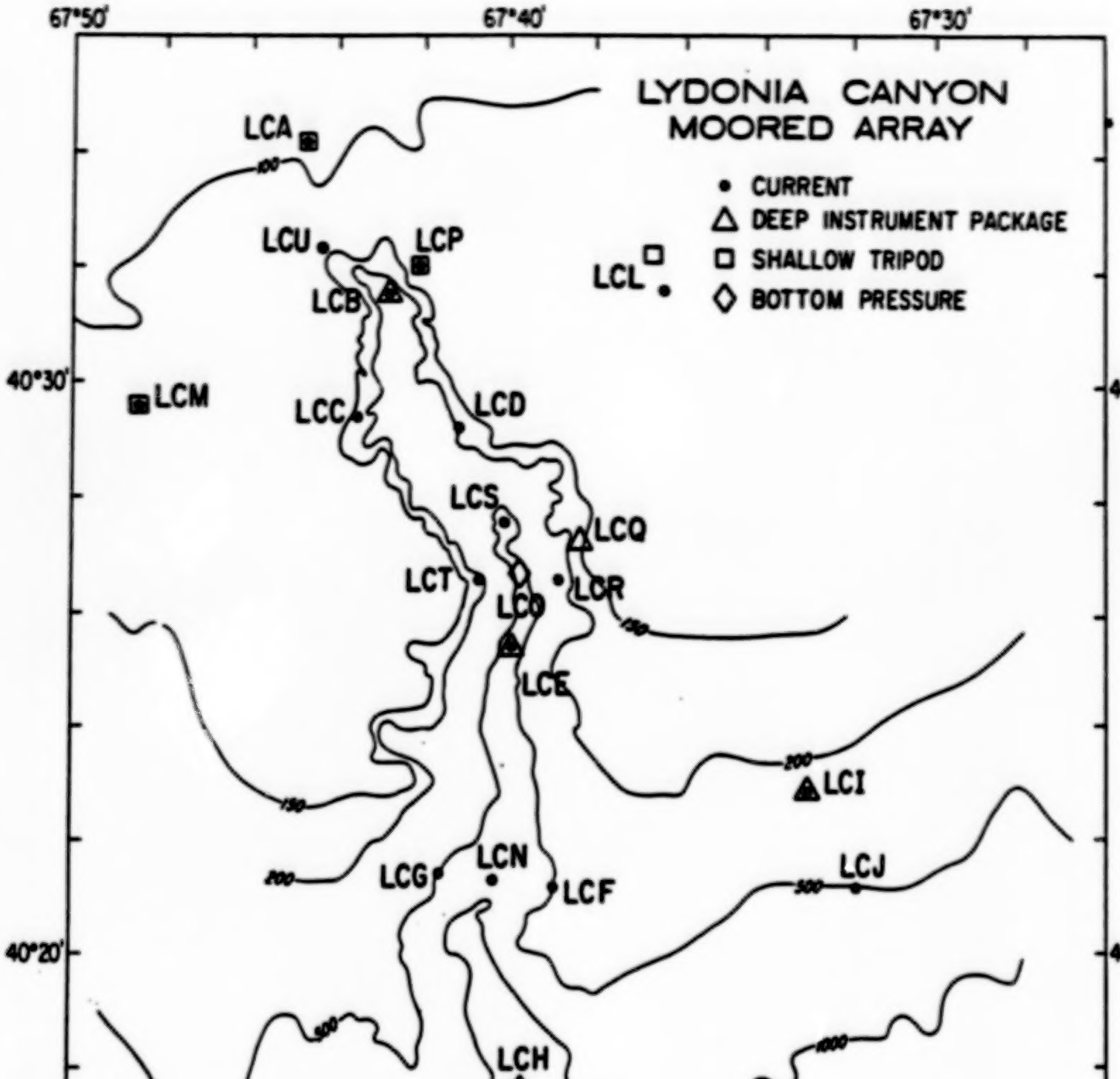

Figure 10. Location of moorings deployed in Lydonia Canyon and on the adjacent shelf and slope. (Source: MMS Interagency Agreement No. 14-12-0001-30180).

North Atlantic

Drill Site Monitoring

73

BLM CONTRACT NO.: AA851-CT1-69
MMS CONTRACT NO.: 14-12-0001-29190

Title: Analysis of Historical Benthic Infaunal Samples from Georges Bank

Date: 30 September 1981 - 18 March 1983

Cost: $100,706

Prime Contractor:
Taxon, Inc.
50 Grove Street
Salem, Massachusetts 01970

Program Manager:
Allan Michael

Principal Participants:
Charlene Long
Richard McGrath

Contracting Officer:
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland

Key Words:
Georges Bank study; benthic studies; population, density, estimates; distribution; invertebrates-general treatment of topic; polychaetes; amphipods; mollusks

Objectives:
This study is part of the Georges Bank monitoring program which is designed to address the following specific questions:

1. What are the quantities, the physical characteristics, and the chemical composition of materials discharged during Outer Continental Shelf (OCS) drilling operations?

2. Where do discharged materials accumulate (e.g., heads of submarine canyons, the "mud patch", around rigs) and in what concentrations?

3. What are the existing background levels of contaminants in the sediments and biota and what levels above background can be detected with state-of-the-art technology?

4. Do benthic populations change at selected regions on Georges Bank during various stages of OCS oil and gas activity compared with control sites; can these changes be related to observed changes in pollutant levels associated with discharges; and what are the

concentrations of pollutants associated with these changes?

Summary:
Benthic infaunal samples were collected with a 0.1 m^2 Van Veen grab at a number of stations on Georges Bank and adjacent areas in 1977. Replicate samples were collected quarterly and sieved to 0.5 mm. Samples were analyzed from 11 of these stations that coincided with stations that were sampled during the more recent Georges Bank Monitoring Program. Approximately 700 taxonomic categories were identified. Polychaetes were numerically dominant in a majority of samples and represented the greatest proportion of species. The next most abundant and diverse group was amphipods, followed by mollusks and then echinoderms. Thirteen polychaete families containing the dominant polychaete species on Georges Bank were discussed individually. Taxonomic problems were enumerated in relation to other studies and the specific solution employed in resolving each difficulty was given.

The number of species found in any one replicate sample ranged from a low of 10 at the top of the bank to a high of 92 in the Gulf of Maine. Numbers of species present increased during the spring-summer period in all but three of the deeper stations. Mean densities of all species ranged from 1,000 individuals per square meter in winter at the top of the bank to over 40,000 individuals per square meter at one station in the Gulf of Maine. Numbers of individuals present increased with depth and in an east-to-west gradient across the bank. Seasonal trends in species densities occurred at the shallower stations.

Biomass measurements showed greater variability between analysts than did other biological parameters (the author suggests using caution when evaluating the results). Values ranged from 7.81 g m^{-2} at the shallowest station to 26.47 g m^{-2} at one station on the east side of the bank near the 100 m contour. Polychaetes comprised 88 per cent of the total biomass measured.

Typically, 6 to 10 species represented more than 90 per cent of the individuals at any given station. Six species occurred in 50 per cent or more of all samples: the polychaetes *Aricidea catherinae*, *Exogone hebes*, *E. brevicornis*, and *Notomastus latericeus*, and the amphipods *Ampelisca agassizi* and *Unciola irrorata*. *Ampelisca agassizi* was perhaps the most characteristic species of the southern flank of Georges Bank occurring in densities of over 1,000 individuals per square meter at seven stations.

The two shallow stations located on Georges Bank had the lowest Shannon-Weaver diversity. Higher values were typical of deeper stations. Variation in Shannon-Weaver diversity between cruises was partially attributed to taxonomic variance.

A high degree of persistence in the fauna present at most stations was reported. Only the most shallow station located on top of the bank had a high level of variability in both the fauna and the sediments sampled.

Intra-sample variance was relatively low even though in some cases replicates were spread over a circle with a radius of 500 to 800 m.

The benthic data gathered in the 1977 Benchmark Program and analyzed during this study indicated that the prospects for using the benthos as a monitoring tool on Georges Bank were good for the following reasons: (1) there are large areas on Georges Bank inhabited by the same or similar benthic communities; (2) replicate sampling within those areas showed low variability, thus enhancing the possibility of detecting statistically significant changes; (3) the persistence of these communities is high. Repeated visits to the same general locality indicated a similar fauna; and (4) the possibility of finding suitable control sites for experimental monitoring stations on the southern flank of the bank is good. Faunal composition is sufficiently similar to provide adequate control sites.

Final Report:

Georges Bank benthic infauna historical study. (A.D. Michael, C.D. Long, D. Maurer, R.A. McGrath; 1983).

Availability:

Available from NTIS:
Final Report - PB83-252114

Other Related Contracts Within This Study Program:

CT2-07/29192
CT2-33/29198
IA2-18/29194
30001
30025
30153

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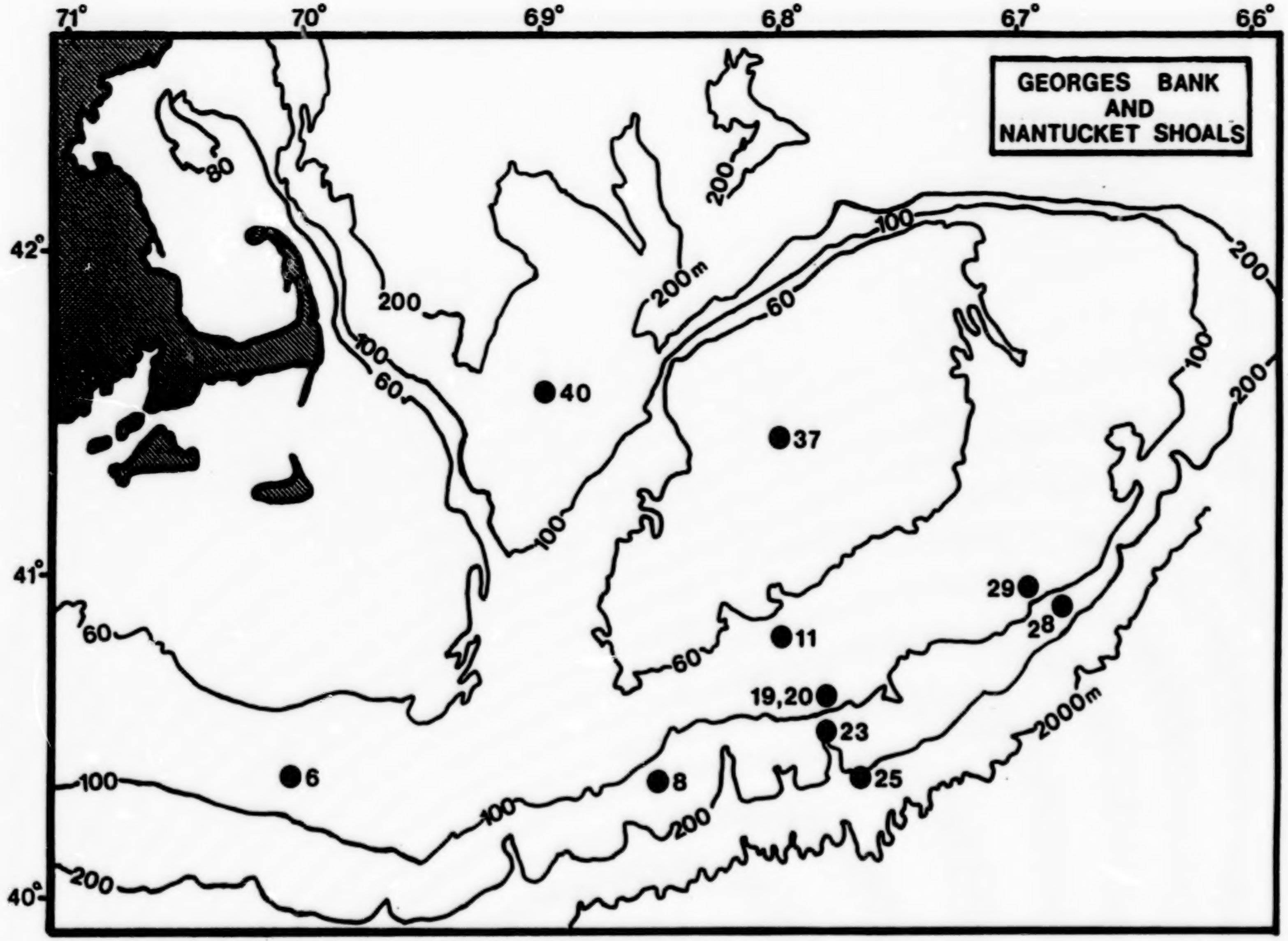

Figure 11. Location of sampling stations. (Source: MMS Contract No. 14-12-0001-29190).

BLM CONTRACT NO.: **AA851-CT2-07**
MMS CONTRACT NO.: **14-12-0001-29192**

Title: Georges Bank Benthic Infauna Monitoring, Year 1-3

Date: 21 January 1982 - March 1985

Cost: $3,998,016

Prime Contractor:
Battelle New England Marine Research Laboratories (BNEMRL)
397 Washington Street
Duxbury, Massachusetts 02332

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)

Chartered Research Vessels:
R/V Endeavor
R/V Gyre
R/V Oceanus
R/V Cape Henlopen

Program Manager:
Jerry M. Neff

Principal Participants:
Nancy Maciolek-Blake
J. Frederick Grassle (WHOI)
George Hampson (WHOI)
Howard L. Sanders (WHOI)

Contracting Officer:
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland
Rosalind E. Cohen
Alyce T. Fritz

Key Words:
Georges Bank study; benthic studies; drill site monitoring; clams; polychaetes; drilling muds/cuttings

Objectives:
This study is part of the Georges Bank Monitoring Program which is designed to address the following specific questions:

1. To determine pre-drilling characteristics of benthic communities in the Georges Bank Lease Sale 42 area.

2. To monitor potential changes in these pre-drilling characteristics with time, and determine whether the changes are caused by drilling-related activities or

whether they are the result of other phenomena including natural temporal or spatial variation.

Summary:

First and Second Years: Concerns about the potential effects of oil and gas exploration activities on the highly productive Georges Bank off the coast of Massachusetts led to the initiation of a monitoring program in July 1981. The program included intensive sampling of the benthic communities, collected near, upcurrent, and downcurrent of the drilling rigs; analysis of bottom photographs for epifauna and microtopography; dredge and trawl collections of bottom fauna; and CHN and sediment grain size analysis. Collections of six replicate infaunal samples at each of 46 stations were made on a seasonal basis. Samples were collected with a 0.04 m^2 modified Van Veen grab sampler and were double live-sieved through 0.5 mm and 0.3 mm screens. Twenty-nine stations were positioned in a tight radial array around one rig at 80 m. A second group of three stations were near a rig site at 145 m. The remaining stations covered a broad expanse of the Bank and nearby areas of potential deposition of drilling materials. Use of the 0.3 um screen resulted in the retention of newly settled and juvenile forms, as well as small-bodied species which are normally poorly sampled by larger screens. The ability to identify the earliest juvenile stages of several species enabled accurate counts of each species and prediction of times of settlement. Results from the first four biological collections indicated little heterogeneity within stations, with good replication between samples. A strong relationship between faunal composition and both sediment type and depth was indicated by cluster analysis. No biological impacts attributable to drilling activities have been detected to date at any station, including the site-specific array in Block 312, the three stations near the drill rig in Block 410, or any regional station monitored in this program.

Third Year: No significant changes in benthic infaunal community structure which can be attributed to the drilling of eight dry wells on Georges Bank were detected during and for at least two years after drilling by the methods of analysis used. Biological patterns in benthic infauna were similar throughout the three years of the Monitoring Program. Abundance of individual species and overall benthic community structure changed very little with season at any station. At stations at or deeper than 100 m (e.g., Stations 3, 6, 8, 9, and Block 410), the samples were very homogeneous within years and it was possible to resolve subtle differences between years. During the three years of the Monitoring Program, the replicate infaunal samples from each regional station showed an exceptionally high degree of homogeneity. Cluster analysis demonstrated that all of the replicates of any one regional station were more similar to each other than to replicates from any other station. The benthic community of any particular station was always distinct from the community at any other station. When replicates from each sampling date were summed, the samples from each of the 12 sampling periods clustered together before joining with samples form any other station. Biomass varied over time and among stations. At some stations there were significant increases in biomass between the first and second years. Clams (Artica islandica) and sand dollars (Echinarachnius parma) dominated the biomass when they were present. When A. islandica and E. parma were absent, polychaetes and arthropods dominated the biomass. Levels of wet-weight biomass found in this study were similar to estimates from other studies. Bottom photographs taken during the Monitoring Program revealed depth-related patterns of microtopography. On the 60 m contour, well-defined ripples were present most of the year. Seasonal differences in ripple patterns were seen at stations along the 70-80 m contour, including the site-specific array in Block 312. Such differences were not seen at stations along the 100 m contour, where little rippling of sediments was noted. Seasonal differences in sediment microtopography were seen at the Block 410 stations at 145 m. Results of the faunal analysis of the photographs corroborated the results of the grab sample analysis. For example, the patchy distribution of the sand dollar Echinarachnius parma at the 60 m stations was obvious in both analyses.

Final Reports:

The Georges Bank Benthic Infauna Monitoring Program. (J.A. Blake, J.F. Grassle, N.M. Blake, J.M. Neff, H.L. Sanders; 1983).

Georges Bank Benthic Infauna Monitoring Program: Final Report for the Second Year of Sampling. (N. Maciolek Blake, J.F. Grassle, J.A. Blake, J.M. Neff; 1984).

Georges Bank Benthic Infauna Monitoring Program: Final Report for the Third Year of Sampling. (N. Maciolek Blake, J.F. Grassle, J.M. Neff; 1985).

Availability:

A review copy of the Third Year report is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS:
Set PB89-220693/AS
Final Report, Year 1 - PB83-204529
Executive Summary, Year 1 - PB83-204511
Final Report, Year 2 - PB84-169457
Final Report, Year 3, Vol I. PB89-220701/AS;
Vol. II. PB89-220719/AS; Vol. III. PB89-220727/AS;

Other Publications/Reports:

Blake, J.A. 1988. New species and records of Phyllodicidae (Polychaeta) from Georges Bank and other areas of the western North Atlantic. Sarsia 73:245-257.

_______________. In Press. Revision of some genera and species of Cirratulidae from the western North Atlantic. Proceedings of the Second International Polychaete Conference, Copenhagen, 1986.

Coates, K. and C. Erseus. 1985. Marine enchytraeids (Oligochaeta) of the coastal Northwest Atlantic (northern and mid U.S.A.). Zoologica Scripta 14(2):103-116.

Collie, J.S. 1985a. Feeding habits of the yellowtail flounder and production of its invertebrate prey on Georges Bank. Ph.D. Thesis. MIT/WHOI, WHOI-85-32. Woods Hole, MA: Woods Hole Oceanographic Institute, 165 p.

_______________. 1985b. Life history and production of three amphipod species on Georges Bank. Marine Ecology Progress Series 22:229-238.

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Collie, J.S. 1987. Food selection by yellowtail flounder (*Limanda ferruginea*) on Georges Bank. Canadian Journal of Fisheries and Aquatic Sciences 44:357-367.

Davis, D. 1984. *Olavius* *cornuatus* sp. n. (Oligochaeta, Tubificidae) from Georges Bank (NW Atlantic). Zoologica Scripta 13(4):273-275.

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Erseus, C. 1984. Taxonomy of some species of *Phallodrilus* (Oligochaeta: Tubificidae) from the Northwest Atlantic, with description of four new species. Proceedings of the Biological Society of Washington 97(4):812-826.

Erseus, C. and D. Davis. 1984. Three new species of *Adelodrilus* (Oligochaeta: Tubificidae) from Georges Bank (NW Atlantic). Proceedings of the Biological Society of Washington 97(4):834-843.

Erseus, C. and D.R. Strehlow. 1986. Four new interstitial species of marine Oligochaeta representing a new family. Zoologica Scripta 15(1):53-60.

Grassle J. F. and N.J. Maciolek. In Preparation. Changes in benthic species diversity with depth: Coastal, shelf, and slope environments. To be submitted to Science.

Maciolek, N.J. 1984. A new species of Polydora (Polychaeta: Spionidae) from deep water in the North-west Atlantic Ocean, and new records of other polydorid species. Sarsia 69:121-131.

Maciolek, N.J., V. Starczak, and J.F. Grassle. In Preparation. The structure of benthic communities on Georges Bank. 2. Animal-sediment relationships.

Maciolek, N.J., J.A. Blake, and J.F. Grassle. In Preparation. The structure of benthic communities on Georges Bank. 3. Population structure and life history of dominant species.

Maciolek-Blake, N., J.A. Blake, J.F. Grassle, and J.M. Neff. 1983. Georges Bank benthic infauna monitoring program--Year 1. In: Proceedings of Oceans '83. 5 p.

________________. In Preparation. The Structure of benthic communities on Georges Bank. 1. Description, diversity, and classification of the communities.

________________. 1987. Variability of the benthic fauna, II. The seasonal variation, 1981-1982. In: Georges Bank. R.H. Backus (ed.). Cambridge, MA: The MIT Press, pp. 303-309.

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Neff, J.M. 1987. The potential effects of drilling effluents on marine organisms on Georges Bank. In: Georges Bank. R.H. Backus (ed.). Cambridge, MA: The MIT Press, pp. 531-549.

Neff, J.M., M. Bothner, N. Maciolek, J.F. Grassle, and J. Payne. In Press. Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. Marine Environmental Review.

Other Related Contracts Within This Study Program:

CT1-69/29190	30001
CT2-33/29198	30025
IA2-18/29194	30153

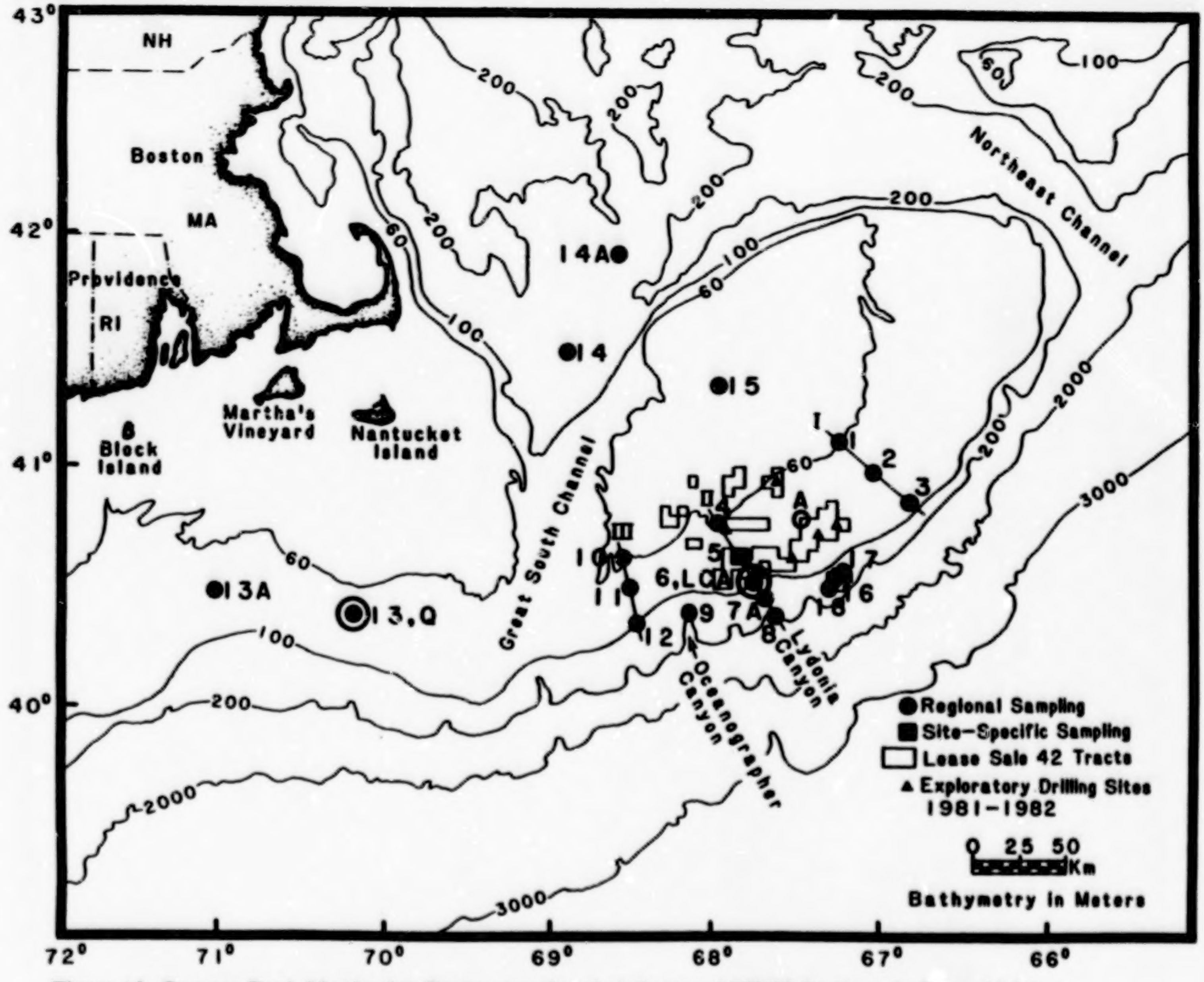

Figure 12. Georges Bank Monitoring Program regional stations and USGS Stations A, Q, and LCA. (Source: MMS Contract No. 14-12-0001-29192).

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BLM CONTRACT NO.: AA851-CT2-33
MMS CONTRACT NO.: 14-12-0001-29198

Title: Georges Bank Monitoring Program: Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in Benthic Fauna, Year 1

Date: 7 May 1982 - 28 May 1983

Cost: $103,941

Prime Contractor:
Science Applications, Inc. (SAI)
Division of Environmental Chemistry and Geochemistry
476 Prospect Street
La Jolla, California 92308

Chartered Research Vessels:
(see Contract No. 29192)

Program Manager:
James R. Payne

Principal Participants:
James R. Payne

Contracting Officer:
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland

Key Words:
Georges Bank study; hydrocarbons; chemical analyses; trace metals; benthic studies; drilling muds; drill site monitoring; clams

Objectives:
This study is part of the Georges Bank Monitoring Program which is designed to address the following specific questions:

1. What are the quantities, the physical characteristics, and the chemical composition of materials discharged during Outer Continental Shelf (OCS) drilling operations?

2. Where do discharged materials accumulate (e.g., heads of submarine canyons, the "mud patch", around rigs) and in what concentrations?

3. What are the existing background levels of contaminants in the sediments and biota and what levels above background can be detected with state-of-the-art technology?

4. Do benthic populations change at selected regions on Georges Bank during various stages of OCS oil and gas activity compared with control sites; can these changes be related to observed changes in pollutant levels associated with discharges; and what are the concentrations of pollutants associated with these changes?

Summary:
Hydrocarbon and trace metal samples were collected and analyzed from a site-specific array of 29 stations located around an exploratory drilling rig in Block 312 and from a series of regional stations located throughout the Georges Bank area. Hydrocarbon analyses of selected drilling fluids, benthic sediments, and epifaunal tissue were conducted. Trace metal analyses were made of benthic fauna. Quarterly samples were taken. Sediments analyzed for hydrocarbons were collected in replicates of three with a 0.1 m^2 Teflon-coated VanVeen grab sampler. Collections of benthic epifauna were made in two ways: (1) filter feeders were collected using a modified rocking chair dredge; and (2) predators and demersal fishes were collected with a 10m otter trawl.

The highest and most variable aliphatic and aromatic hydrocarbon levels were observed in the area down current from Georges Bank known as the Mud Patch. This area, believed to be a depositional site for sediments, was characterized as having the finest grain size of any stations examined. The majority of the hydrocarbons detected here were believed to be from biogenic sources including marine algae and terrestrial plants. Aromatic hydrocarbons were thought to come from atmospheric fallout of combustion products, chronic low level inputs from sewage and waste water disposal, and weathered petroleum from tankers and shipping related discharges. Overall, aromatic hydrocarbon levels were extremely low and essentially constant over time at the benthic stations sampled. There were significant differences in absolute aromatic hydrocarbon levels between stations. There was no significant accumulation of aliphatic or aromatic hydrocarbons from exploratory drilling activities in Block 312, but this was attributed to the scouring and winnowing process of the currents in that area.

Analyses of four drilling fluid samples obtained from the semi-submersible drilling rig in Block 312 showed the presence of hydrocarbons in the range of 23 to 480 mg l^{-1}. Comparisons of the chromatographic profiles of the drilling fluids hydrocarbon component with sediment sample extracts from both site-specific and regional stations showed little evidence to suggest any drilling fluid accumulation. There was little or no evidence to suggest that any hydrocarbon compounds associated with drilling fluids were accumulating in the tissues of the species analyzed. One sample of the black clam, Arctica islandica, yielded a selected ion monitoring profile which suggested that trace levels (<1 ng g^{-1} dry weight) of alkyl-substituted polynuclear aromatic hydrocarbons common to drilling fluids may have been present; however, the chromatogram of the aliphatic fraction showed no evidence of the characteristic profiles observed in drilling fluid analyses.

No evidence of change in the levels of trace metals present within the biota could be found during the four cruises of this monitoring program. Furthermore, there were no significant changes in levels of Cd, Cr, Cu, Fe, Ni, Pb, and Zn in tissue samples of *A. islandica* collected during this program when compared to those collected during the 1977, New England OCS Environmental Benchmark Program.

Final Report:

Georges Bank Monitoring Program: Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in Benthic Fauna. (SAI; 1982).

Availability:

Available from NTIS:
- Final Report - PB83-180778
- Appendices - PB83-180786

Other Related Contracts Within This Study Program:

CT1-29/29190
CT2-07/29192
IA2-18/29194
CT5-29/29169
30001
20025
30153

MMS CONTRACT NO. 14-12-0001-30001

Title: Georges Bank Monitoring Program: Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in the Benthic Fauna, Years 2-3

Date: 31 January 1983 - March 1985

Cost: $292,021

Prime Contractor:

Science Applications, Inc. (SAI)
Division of Environmental Chemistry and Geochemistry
476 Prospect Street
La Jolla, California 92308

Chartered Research Vessels:

(see Contract No. 29192)

Program Manager:

James R. Payne

Principal Participants:

James R. Payne

Contracting Officer:

Jeffrey P. Petrino

COTR:

Jeffrey L. Hyland
Rosalind E. Cohen
Alyce T. Fritz

Key Words:

Georges Bank study; hydrocarbons-chemical analyses; trace metals; benthic studies; drill site monitoring; clams

Objectives:

This study is part of the Georges Bank Monitoring Program. Specific objectives of this study are to:

1. Determine pre-drilling levels and distribution of hydrocarbons in bottom sediments throughout the Georges Bank Lease Sale 42 area.
2. Monitor potential changes in sediment hydrocarbon levels with time, and determine whether these changes are related oil and gas drilling discharge activities and predicted patterns of dispersion from the drill sites.
3. Identify areas of hydrocarbon accumulation within the study area, and estimate rates of accumulation and release from the sediments.

4. Determine pre-drilling levels of hydrocarbons and trace metals in benthic fauna throughout the Georges Bank Lease Sale 42 area.

5. Monitor potential changes in levels of hydrocarbons and trace metals in benthic fauna, and determine whether these changes are related to drilling discharge activities and predicted patterns of dispersion from the drill sites.

Summary:
Second year results: Aromatic hydrocarbons, as measured by UV/Florescence, were present in low (100 ng g^{-1} dry weight) concentrations in sediments immediately around the drill rig, Rowan Midland, before drilling was initiated. Approximately 2 months after drilling began, an apparent increase in sediment aromatic hydrocarbons occurred immediately around the rig; concentrations approaching 400 ng g^{-1} dry weight were observed 5 to 6 months after the onset of drilling, and remained fairly constant for up to 11 months after the drilling was discontinued. Attempt to confirm the presence of drilling fluid components in sediment extracts by FID-GC and GC/MS analyses were inconclusive due to higher detection limits of these techniques. Several individual polynuclear aromatic hydrocarbons were identified at 1-10 ng g^{-1} dry weight concentrations, but direct correlations width aliphatic and aromatic components in the drilling fluids were not obtained.

Results of UV/florescence analyses at stations further than 2 km from the rig indicated no significant changes in aromatic hydrocarbon concentration in the sediments. Evidence of petrogenic hydrocarbons was found in several natural depositional regimes around the periphery of Georges Bank; however, the concentrations and chemical composition of these materials did not change appreciable after drilling began.

There was no evidence of drilling fluid-related hydrocarbon accumulation in the epifaunal tissues analyzed. Trace metal concentrations, including Ba, in two species (Arctica islandica and Paralichthys oblongus) were uniformly low for all elements.

Third year results: Concentrations of both hydrocarbons in surficial sediments and hydrocarbons and trace metals in tissue were low throughout the Year Three Monitoring Program. Levels of total aromatics in sediments at the site-specific stations were less than 1 ug/g dry weight, and consistent with the base line levels as measured in previous studies. Concentrations of aromatic hydrocarbons at the regional monitoring stations were slightly higher, but also were consistent with the corresponding basement values. Increases in concentrations of total aromatics in sediments at a station 0.5 km from the drilling site concurrent with drilling activities, and the presence of specific perrogentc hydrocarbons in sediment extracts that also were detected during the previous analyses of discharged drilling fluids, provided evidence of short-term deposition of drilling discharge materials in the near-field bottom sediments.

Drilling fluid residues were not observed in sediments collected at the station one month after drilling operations were terminated, suggesting relatively short residency times. Furthermore, drilling fluid residues were not observed in sediment from other near-rig or regional stations located at relatively greater distances from the drilling site, either during or subsequent to the drilling activities. No uptake or accumulation of drilling fluid components was detected in tissues of Arctica islandica during the Year Three monitoring program. Hydrocarbon and trace metal burdens in tissues were low, and consistent with corresponding basement and pre-drilling levels.

Final Report:

Georges Bank Monitoring Program: Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in Benthic Fauna During the Second Year of Monitoring. (J.R. Payne, J.L. Lembach, R.E. Jordan, C.R. Phillips, G.D. McNabb, M.K. Beckel, G.H. Farmer, R.R. Sims, J.G. Sutton, A. Abasumara; 1983).

Georges Bank Monitoring Program: Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in Benthic Fauna During the Third Year of Monitoring. (J.R. Payne, J.L. Lambach, G.H. Farmer, C.R. Phillips, M.K. Beckel, J.G. Sutton, and R.R. Sims, Jr.; 1985).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia. Final Report - Third Year
Available from NTIS:
Final Report, Second Year - PB84-141449

Other Publications/Reports:

Payne, J.R., J.R. Clayton, Jr., C.R. Phillips, J.L. Lambach, and G.H. Farmer. 1985. Marine oil pollution index. Oil and Petrochemical Pollution 2:173-191.

Phillips, C.R., J.R. Payne, J.L. Lambach, G.H. Farmer, and R.R. Sims, Jr. 1987. Georges Bank Monitoring Program; hydrocarbons in bottom sediments and hydrocarbons and trace metals in tissues. Marine Environmental Research 22:1-42.

Other Related Contracts Within This Study Program:

CT1-69/29190
CT2-07/29192
CT2-33/29198
IA2-18/29194
30025
30153

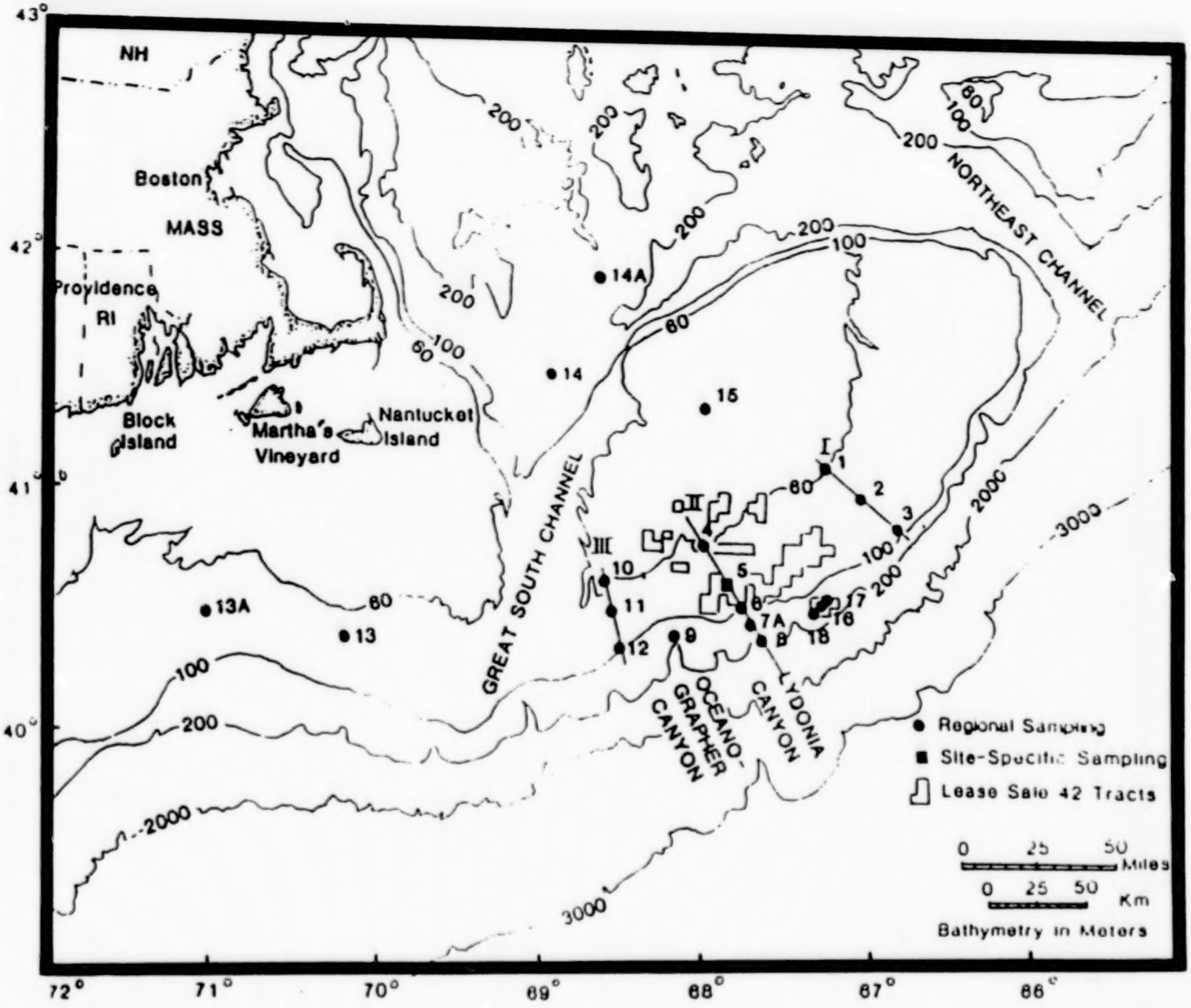

Figure 13. Location of "Georges Bank Monitoring Program" sampling sites. (Source: MMS Contract No. 14-12-0001-30001).

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BLM INTERAGENCY AGREEMENT NO.: **AA851-IA2-18**
MMS INTERAGENCY AGREEMENT NO.: **14-12-0001-29194**

Title: Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments, Year 1

Date: 25 March 1982 - 28 June 1983

Cost: $324,847

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Chartered Research Vessels:
(see Contract No. 29192)

Program Manager:
Michael H. Bothner

Principal Participants:
Michael H. Bothner

Contracting Officer:
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland

Key Words:
Georges Bank study; drill site monitoring; trace metals; sediments (geology); chemical analyses-trace metals; drilling discharges

Objectives:
This study is part of the Georges Bank Monitoring program which is designed to address the following specific questions:

1. What are the quantities, the physical characteristics, and the chemical composition of materials discharged during Outer Continental Shelf (OCS) drilling operations?
2. Where do discharged materials accumulate (e.g., heads of submarine canyons, the "mud patch", around rigs) and in what concentrations?
3. What are the existing background levels of contaminants in the sediments and biota and what levels above background can be detected with existing state-of-the-art technology?
4. Do benthic populations change at selected regions on Georges Bank during various stages of OCS oil and gas activity compared with control sites; can these changes be related to observed changes in the pollutant levels

associated with discharges; and what are the concentrations of pollutants associated with these changes?

Summary:
The data base included 18 regional stations located across Georges Bank, 29 site-specific stations located around a drill site in Block 312, and three stations located around a drilling rig in Block 410. Four cruises were conducted. A pre-drilling cruise occurred in July 1981. The remaining cruises occurred in November 1981 and in February and May 1982. Samples were taken with a 0.1 m^2 stainless steel VanVeen grab sampler with Teflon coating on all contact surfaces. Extensive precautions were taken to prevent sample contamination. Samples were dried to a constant weight at 40°C in a Teflon-coated oven with a filtered nitrogen atmosphere. Grain size analysis was performed by a Rapid Sediment Analyzer and the gravimetric determination of silts and clays by filtering. Trace metals analyzed were: aluminum (Al), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), vanadium (V), and zinc (Zn). Organic carbon was analyzed only on the first cruise. Analytical precision was determined by periodically analyzing five replicate aliquots taken from a single sample and determining the coefficients of variation. Accuracy was determined by comparisons with standard solutions.

The sediments on Georges Bank were typically greater than 95 per cent sand with minor amounts of gravel, silts, and clays. The sand was quartzose, medium to coarse grained. Concentrations of silts and clays were generally less than 2 per cent on the bank itself, but higher (4 to 18%) in the Gulf of Maine, at Lydonia Canyon (2 to 4%), and south of Nantucket Island (38 to 97%).

The gravel fraction was variable throughout the study area (0 to 30%). Drilling cuttings were observed within the gravel fractions from stations within 200 m of the two drill sites monitored. No evidence of cuttings was found farther than 200 m from the drilling rigs.

Concentrations of metals in average crustal material and in average sandstone were compared to the pre-drilling metal concentrations. With the exception of Pb, the highest concentration observed in pre-drilling samples was below concentrations found in mean crustal rocks, indicating the sediments from Georges Bank were uncontaminated by heavy metals. The observed increase in Pb was attributed to the use of tetraethyl lead in gasoline. One station south of Nantucket Island, characterized by a higher percentage of fine sediments (56% sand, 23% silt, 21% clay), was also characterized by a higher concentration of heavy metals, suggesting that this area may be a modern sink for pollutants that are reactive with fine-grained, organic-rich sediments.

Ba (present in barite, a major component of drilling muds) increased by a factor of 3.5 in the bulk (unfractionated) sediments within

200 m of the drill site in Block 410. Average Ba concentrations rose from 30 to 107 ppm. A small increase was observed 2,000 m from the drill site in this block. In Block 312, where the intensive site-specific survey was conducted, Ba concentrations in bulk sediments increased by a factor of 2.3 (from 40 to 91 ppm) as a result of drilling. Increases of small magnitude were observed up to 6 km from the rig. It is important to note that Ba concentrations in excess of 100 ppm were measured at Georges Bank stations even before drilling began. No drilling-related changes in the concentration of Cr or other metals were observed in bulk sediments from Block 312 or 410.

Separation and analysis of the sediment fraction finer than 0.062 mm, which typically represented less than 3 per cent of the total sediments at Georges Bank, improved the ability to detect Ba increases due specifically to drilling discharges. Ba in the fine sediments of Block 410 increased from the pre-drilling level by a factor of 36 (242 to 8,640 ppm). In Block 312, a Ba increase of 22 times the pre-drilling level was reported from the fine sediments. Increases in Al, Cr, Cu, and Hg in the fine sediment fractions at Block 410 were reported. The highest concentrations measured, however, were only equivalent to average crustal material values.

Concentrations of Al, Ba, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, V, and Zn in the surface sediments of Georges Bank, both before and after drilling, are low compared to average crustal abundances and are characteristic of unpolluted, coarse grained sediments found in other areas of the continental shelf. No drilling-related changes in the concentrations of Cr or other metals were observed in the bulk sediments from Block 312 or 410 where exploratory wells were drilled.

Final Report:

The Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments. (M.H. Bothner, R.R. Rendigs, E. Campbell, M.W. Doughten, P.J. Aruscavage, A.F. Dorrzapf, R.G. Johnson, C.M. Parmenter, M.J. Pickering, D.C. Brewster, F.W. Brown; 1982).

Availability:

Available from NTIS:
Final Report - PB8-3174888

Other Publications/Reports:

Bothner, M.H., B. Butman, H.S. Bolton, J.L. Hyland, and E. Imamura. 1982. The Georges Bank Monitoring Program: Present and future status (abs.). EOS: Transactions, American Geophysical Union 63:351.

Bothner, M.H., R.R. Rendigs, E. Campbell, M.W. Doughten, P.J. Aruscavage, A.F. Dorrzapf, Jr., R.G. Johnson, C.M. Parmenter, M.J. Pickering, D.C. Brewster, and F.W. Brown. 1983. The Georges Bank Monitoring Program: Analysis of trace metals in bottom sediments. U.S. Geological Survey Circular 915, 36 p.

Butman, B., M.H. Bothner, D.C. Twichell, and D.W. O'Leary. 1982. Present environmental studies of Georges Bank conducted by the U.S. Geological Survey. In: Workshop Proceedings, Georges Bank Energy Activity: An update. Kingston, RI: Center for Ocean Management Studies, University of Rhode Island, pp. 26-43.

Other Related Contracts Within This Study Program:

CT1-69/29190	30001
CT2-07/29192	30025
CT2-33/29198	30153

MMS INTERAGENCY AGREEMENT NO. 14-12-0001-30025

Title: Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments, Year 2

Date: 5 May 1983 - November 1983

Cost: $317,587

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Chartered Research Vessels:
(see Contract No. 29192)

Program Manager:
Michael Bothner

Principal Participants:
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Erma Campbell
M.W. Doughten
J.R. Gillison
R.G. Johnson
C.M. Parmenter
M.J. Pickering
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Contracting Officer:
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland

Key Words:
Georges Bank study; trace metals; drilling discharges; drill site monitoring; sediments(geology); chemical analyses-trace metals

Objectives:
This study is part of the Georges Bank Monitoring Program. Specific objectives of this study were to:

1. Determine pre-drilling levels and distribution of trace metals in bottom sediments throughout the Georges Bank Lease Sale 42 area.

2. Monitor potential changes in trace metal levels with time and determine whether these changes are related to oil and gas drilling discharge activities and predicted patterns of dispersion from the drill sites.

3. Identify areas of trace metal accumulation within the study area, and estimate rates of accumulation and release from the sediments.

Summary:
Samples of surficial, subsurficial, and suspended sediment collected at regional and site-specific stations were subjected to textural and chemical analyses. A total of 18 regional stations (established to evaluate changes across the entire region) and 29 site-specific stations (located near exploratory rigs) were sampled.

Trace metal analyses were conducted for aluminum (Al), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), vanadium (V), and zinc (Zn), using several methods. Al, Cr, Fe, Ni, and V concentrations were determined by inductively coupled plasma spectrometry. Cd, Cu, and Pb concentrations were determined using a graphite-furnace atomic absorption spectrophotometer. Results from Ba and Cr analyses were cross checked by an energy dispersive x-ray fluorescence technique. This method was used to analyze all Ba concentrations exceeding 500 ppm.

Sediments on Georges Bank were comprised mostly of medium to coarse grained, quartzose sand with lesser amounts of gravel, silts, and clays. Silt and clay concentrations were generally less than 4 per cent in regional samples. Significant concentrations of fine sediments detected at regional stations included: the Gulf of Maine (80 to 90% fines); the head of Lydonia Canyon (25 to 30% fines); and the Mud Patch region south of Nantucket Island (92 to 97% fines). Drill cuttings were found in gravel fractions from drill sites in Blocks 312 and 410; some cuttings were found 2 km from the drill site in Block 410 and within 500 m of the drill site in Block 312.

Barite (barium sulfate) increased by a factor of 5.9 in bulk sediments 200 m from the drill site in Block 410 as a result of drilling. Maximum Ba concentrations reached 172 ppm at this site. Because the Ba was in the form of barite, a low toxicity form, no adverse chemical stress to benthic organisms was expected. Of the barite discharged into the waters of Block 312, an estimated 21 to 31 per cent was present in the sediments within 6 km of the drill site. Projections indicated that sediment Ba levels within 6 km of the drill site in Block 312 will return to within 10 per cent of pre-drilling levels in 1.5 years. Barite was found in fine sediments as far as 65 km west of the drilling operations. Enriched Ba concentrations are restricted to the upper 2 cm of the sediment, and any residual Ba will be mixed deeper into the sediment column by physical and biological processes.

Final Report:
The Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments During the Second Year of Monitoring. (M.H. Bothner, R.R. Rendigs, E. Campbell, M.W. Doughten, C.M. Parmenter, M.J. Pickering, R.G. Johnson, J.R. Gillison; 1983).

Availability:

Available from NTIS:

Final Report - PB84-169465

Other Publications/Reports:

Bothner, M.H. 1984. Environmental monitoring in Georges Bank: Trace-metal analysis of bottom sediment. In: Highlights in Marine Research. S.H. Clarke (ed.). U.S. Geological Survey Circular 938, pp. 81-89.

Bothner, M.H, R.R. Rendigs, E. Campbell, M.W. Doughten, C.M. Parmenter, M.J. Pickering, R.G. Johnson, and J.R. Gillison. 1983. The Georges Bank monitoring program 1984: Analysis of trace metals in bottom sediments during the second year of monitoring. U.S. Geological Survey Circular 936, 54 p.

Other Related Contracts Within This Study Program:

CT1-69/29190
CT2-07/29192
CT2-33/29198
IA2-18/29194
30001
30153

MMS INTERAGENCY AGREEMENT NO. 14-12-0001-30153

Title: Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments, Year 3

Date: 28 March 1984 - February 1985

Cost: $324,847

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Chartered Research Vessels:
(see Contract No. 29192)

Program Manager:
Michael H. Bothner

Principal Participants:
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Contracting Officer:
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland
Rosalind E. Cohen

Key Words:
Georges Bank study; chemical analyses-trace metals; trace metals; drill site monitoring; sediments (geology); drilling discharges

Objectives:
This study is part of the Georges Bank Monitoring Program. Specific study objectives are to:

1. Determine pre-drilling levels and distribution of trace metals in bottom sediments throughout the Georges Bank Lease Sale 42 area.

2. Monitor potential changes in trace metal levels with time, and determine whether these changes are related to oil and gas drilling discharge activities and predicted patterns of dispersion from the drill sites.

3. Identify areas of trace metal accumulation within the study area, and estimate rates of accumulation and release from the sediments.

Summary:
The monitoring program was conducted to provide data before, during, and after drilling operations which included eight exploratory wells.

Samples of surficial, subsurficial, and suspended sediment were subjected to textural and chemical analyses.

A total of 18 regional stations were established to evaluate changes across the entire region. Twenty-nine site-specific station (located near exploratory rigs) were also sampled. Station location and positioning was accomplished using Loran-C. Sediment samples were collected with a 0.1 m^2 stainless steel Van Veen grab sampler. Sediment traps were deployed at various heights above the sea floor in Block 312 and in Lydonia Canyon. Aluminum (Al), barium (Ba), iron (Fe), manganese (Mn), and mercury (Hg), were determined by induction furnace atomic absorption spectrometry. Results of Ba and Cr analyses from selected samples were confirmed using an energy dispersive x-ray fluorescence technique.

Barium (present in barite, a major constituent of drilling mud) has increased by a factor of 5.9 in bulk (unfractionated) sediments 200 m from the drill site in block 410 as a result of drilling. The maximum barium concentration (172 ppm) was within the range of predrilling concentrations (28 ppm - 300 ppm) measured at other sampling stations of this program. Because of the low toxicity of barium in the form of barite ($BaSO_4$), no adverse chemical stress to bottom-dwelling organisms is expected from these measured increases in barium concentrations. This prediction is being tested by the biological studies conducted within the Monitoring Program. No drilling-related changes in the concentrations of chromium or of other metals have been observed in bulk sediments from any of the locations sampled in this program.

Of the barite discharged to the ocean waters while drilling in Block 312, it was estimated that 25 per cent was present in the sediments within 6 km of the well at the time of the fifth monitoring cruise which was conducted weeks after drilling was completed.

The inventory of barite, which accumulated as a result of drilling in Block 312, has decreased steadily for almost a year during the period following drilling with a "half-life" of 0.34 years. A much slower rate ("half-life" of 3.4 years) is estimated for the period between cruises 8 and 12. At the time of cruise 12, the Ba inventory between 0.5 - 2 km from the well site was approximately 12 per cent higher than the pre-drilling value.

The barite from drilling mud is associated with the fine sediment fraction in low concentration and is widely distributed. Its fate is closely linked to the energetic sediment transport processes characteristic of this region. Evidence was found for Ba transport and deposition to the west of the drilling activity: at stations 10 and 12 along transect III, at new coring stations 50 km west of transects III, in sediment-trap material and sediments from the head of Lydonia Canyon, and from sediments near the head of Oceanographer Canyon. In addition, peaks were found in the concentration of Ba with time at upstream control stations 2 and 3, located 35 km northeast of the nearest drilling activity. The data from sediment-trap analyses suggest that barite which is originally deposited near a drill site in this area can be resuspended to at least 25 m above the sea floor.

Final Report:

The Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments During the Third Year of Monitoring. (M.H. Bothner, R.R. Rendigs, E.Y. Campbell, M.W. Doughten, C.M. Parmenter, C.H. O'Dell, G.P. DiLisio, R.G. Johnson, J.R. Gillison, and N. Rait; 1985).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS:
Final Report - PB85-231967

Other Publications/Reports:

Bothner, M.H., R.R. Rendigs, E.Y. Campbell, M.W. Doughten, C.M. Parmenter, C.H. O'Dell, G.P. DiLisio, R.G. Johnson, J.R. Gillison, and N. Rait. 1985. The Georges Bank Monitoring Program: Analysis of trace metals in bottom sediments during the third year of monitoring. U.S. Geological Survey Circular (in press, as of 8/85).

Other Related Contracts Within This Study Program:

CT1-69/29190
CT2-07/29192
CT2-33/29198
IA2-18/29194
30001
30025

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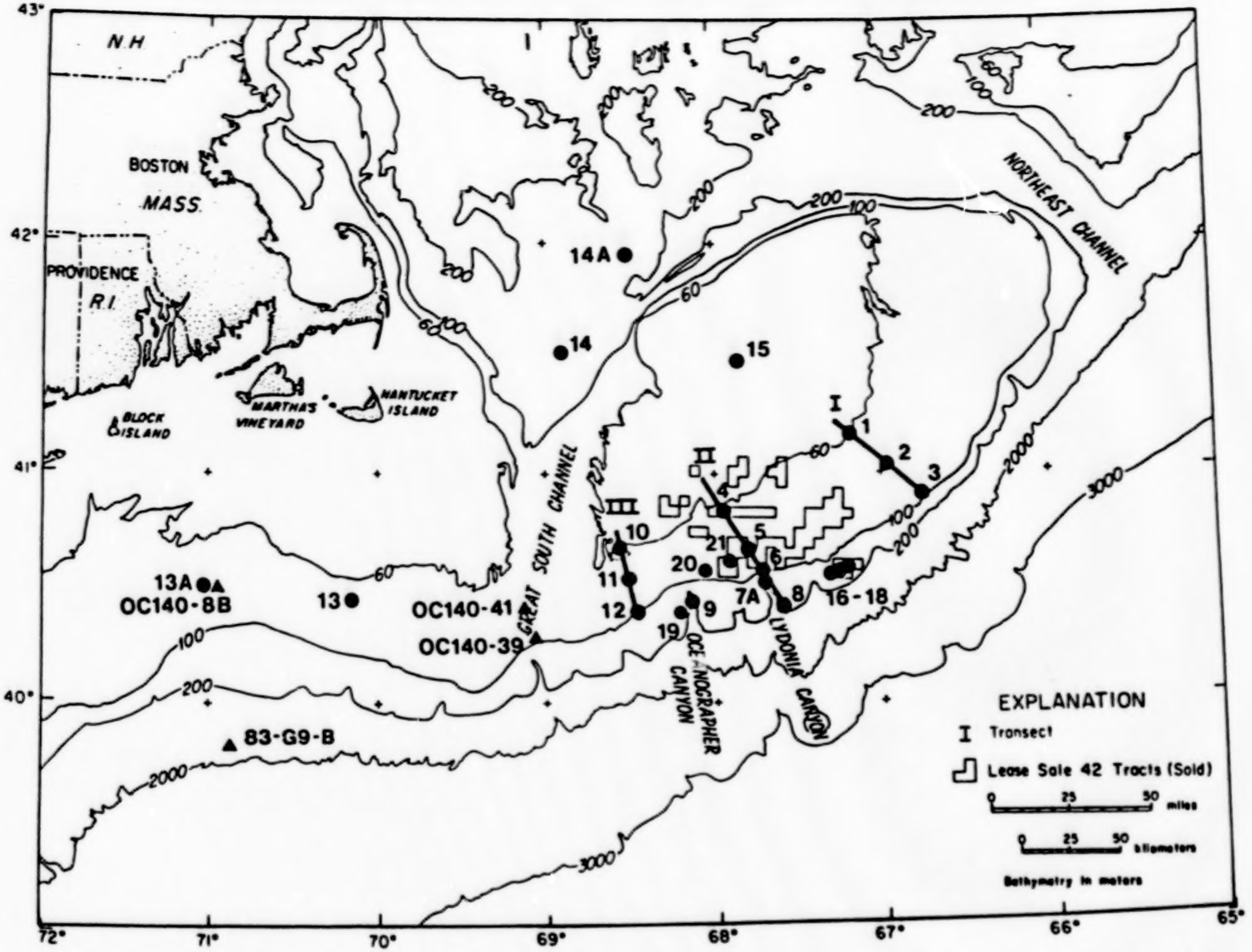

Figure 14. Sampling stations for the "Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments, Year 3." (Source: MMS Contract No. 14-12-0001-30153).

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Mid-Atlantic

Workshops and Conferences

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BLM CONTRACT NO.: CT5-11

Title: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon

Date: November 1974 - November 1974

Cost: $15,000

Prime Contractor:

Estuarine Research Federation (ERF)
Virginia Institute of Marine Science (VIMS)
Wachapreague, Virginia 23480

Principal Participants:

L.E. Cronin
R.E. Smith

Key Words:

conferences/meetings/symposiums; oil and gas resources effects-ecological; fate and effects of oil; oil effects on environment; oil rigs, platforms

Objectives:

1. Provide a summary of available related data for a portion of the continental shelf as designated by the Minerals Management Service in the Mid-Atlantic Region.

2. Provide any predictions presently possible of the effects of drilling (including both exploration and exploitation) on the environment of this area.

3. Identify the areas of knowledge in which additional information is essential for reasonable prediction and understanding of the environmental effects of drilling in this area.

4. Formulate recommendations for baseline and monitoring programs adequate for determination of the environmental effects of oil and gas exploration and exploitation in this area.

Summary:

The Mid-Atlantic Conference Workshop was held to review available knowledge of the region, to state the responsibilities of State and Federal Government Agencies, and to recommend the best approach to baseline and monitoring studies, if oil and gas exploration and development should commence in the Mid-Atlantic Region. The workshop recommended that a comprehensive, interdisciplinary study of the region should be conducted prior to oil and gas activities. Workshop comments were also concerned with sampling schemes and sizes, standardization of equipment and methods, data management systems, and analysis of existing published and unpublished data.

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Final Report:

Marine environmental implications of offshore oil and gas development in the Baltimore Canyon region of the Mid-Atlantic coast: Proceedings of Estuarine Research Federation Outer Continental Shelf and Workshop. (Publication No. ERF 75-1) (L.E. Cronin, R.E. Smith; 1974).

Availability:

A review copy is available from the Minerals Management Service, Herndon, Virginia

Environmental Studies Index

Mid-Atlantic

Environmental Inventories and Assessments

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BLM CONTRACT NO.: AA550-CT5-42 (VIMS)/ MMS
BLM INTERAGENCY AGREEMENT NO.: 08550-MU5-33 (USGS)

Title: Environmental Data Acquisition Analysis - Mid-Atlantic OCS, Year 1

Date: 17 June 1975 - 16 February 1978 (CT5-42)
12 November 1975 - 5 October 1977 (MU5-33)

Cost: $1,873,138 (CT5-42)
$ 978,200 (MU5-33)
$2,851,338

Prime Contractor:
Virginia Institute of Marine Science (VIMS)
Gloucester Point, Virginia 23062

U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
American University (AU)
The Marine Science Consortium, Inc. (MSC)
University of Delaware (UD)
University of Virginia (UV)

Chartered Research Vessels:
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Program Manager:
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V. Goldsmith
G. Grant
R. Huggett
J. Jacobson
R. Jolly
H. Kator
M.P. Lynch
W. MacIntyre
F. Perkins
C. Ruddell
E.P. Ruzecki
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A.F. Guida

COTR: Jeanne Snider
Arthur Horowitz

Key Words:
ecological study; ecological characteristics; hazards-geologic sediment characteristics; chemical analysis; chemical analyses-hydrocarbons; circulation/current study; trace metals; benthic studies; zooplanton; bacteria

Objectives:
The objectives of the first year field studies conducted by VIMS were to:

1. Collect and analyze chemical and biological data on conditions existing prior to oil and gas development.
2. Assess the processes regulating biological communities.
3. Determine levels of chemical constituents in the shelf environment.

USGS program objectives were to:

1. Identify potential geohazards.
2. Determine sediment movement and probable causes.
3. Describe the mineralogy.
4. Assess hydrocarbon levels in sediments and section samples.

Summary:
The Virginia Institute of Marine Science conducted field studies between October 1975 and October 1976 in the Mid-Atlantic. The results of the study indicated: 1) the Mid-Atlantic waters were characterized by three water masses (coastal boundary layer, shelf water, and slope water); 2) eggs and larvae of fishes and crustaceans were significant in the spring neuston; 3) macrobenthos demonstrated little seasonality, and were most dense on the outer shelf; and 4) local ridge and swale topography had a strong influence on the distribution of sediments, on the concentrations of trace metals, hydrocarbons, organic nitrogen, and organic carbon in the sediments, and on the distribution and abundance of the benthic biota.

The U.S. Geological Survey (Woods Hole, Massachusetts) conducted geologic studies on the Mid-Atlantic Outer Continental Shelf (OCS) (Baltimore Canyon Trough Area). The first year results can be summarized: 1) geologic environmental hazards in the area do not warrant withdrawal of lease tracts (Sale 40 area); 2) stress due to waves and currents associated with major storms, bottom sediment mobility, and inherent poor bearing capacity of the sediments may pose problems; and 3) wide-spread dispersal of bottom sediment and suspended matter occurs especially when driven by major storm waves and currents. Recommended studies included determining rates of sediment movement, assessment of the engineering characteristics of the bottom and subbottom, further collection of data on suspended

sediment flux, and continuation of monitoring for trace metal and hydrocarbon concentrations.

Final Report:
Middle Atlantic Outer Continental Shelf Environmental Studies--First Year (M.P. Lynch, D.W. Folger 1977).

Availability:
Available from NTIS:
Set - PB281295
Executive Summary (Vol. I)- PB281296
Final Report (Vol. IIA, Chemical and Biological Benchmark Studies) - PB281297
Final Report (Vol. IIB, Chemical and Biological Benchmark Studies) - PB281298
Final Report (Vol. III, Geologic Studies) - PB281299

Other Publications/Reports:

Bothner, M.H. 1979. Trace metals in surface sediments of the Mid-Atlantic continental shelf. U.S. Geological Survey Open File Report 79-843, 39 p.

Butman, B. and D.W. Folger. 1979. An instrument system for long-term sediment transport studies on the continental shelf. Journal of Geophysical Research 84:1215-1220.

Butman, B., M.A. Noble, and D.W. Folger. 1977. Observations of bottom sediment movement on the Mid-Atlantic continental shelf (abs.). EOS: Transactions, American Geophysical Union 58(6):408.

______________. 1979. Long-term observations of bottom current and bottom sediment transport on the Mid-Atlantic continental shelf. Journal of Geophysical Research 84:1187-1205.

Folger, D.W. 1976. Hazards on the Outer Continental Shelf off the Mid-Atlantic states: A preleasing assessment. Association of Engineering Geologists, 19th Annual Meeting Abstracts p. 17.

_______________. 1979. Geologic conditions in the Baltimore Canyon Trough area: A summary of USGS first-year environmental studies. U.S. Geological Survey Open File Report 79-1552, 26 p.

Folger, D.W., H.J. Knebel, and D.C. Twichell. 1976. Ancestral Delaware River Valley: Evidence for cross shelf extension to Wilmington Submarine Canyon (abs.). Geological Society of America, Abstracts with Programs 8(29):175-176.

Hosom, D.S. 1979. The Sea Data 651-4 data logger. Woods Hole Oceanographic Institution Technical Memorandum 6-79.

Hosom, D.S., and B. Butman. 1981. The Sea Data 651-4 data logger. U.S. Geological Survey Open File Report 81-111. 85 p., 52 figs. 3 tables.

Knebel, H.J., B. Butman, D.W. Folger, P.W. Cousins, and R.R. McGirr. 1976. Maps and graphic data related to geologic hazards in the Baltimore Canyon Trough area. U.S. Geological Survey Miscellaneous Field Studies Map MF-828, 3 sheets.

Knebel, H.J. and D.W. Folger. 1976a. Large sand waves on the Outer Continental Shelf around Wilmington Canyon, off eastern United States. Marine Geology 22:M7-M15.

____________. 1976b. Large sand waves on the Outer Continental Shelf around Wilmington Canyon (abs.). EOS: Transactions, American Geophysical Union 57(4):268.

Knebel, H.J. and N.S. Hardin. 1975. The responsibilities and environmental programs of the U.S. Geological Survey in the Baltimore Canyon Trough area. Proceedings Outer Continental Shelf Conference and Workshop, College Park, MD, pp. 7-17.

Knebel, H.J., C.W. Poag, and E.C. Spiker. 1976. Shallow subbottom stratigraphy, Middle Atlantic Outer Continental Shelf (abs.). Geological Society of America, Abstracts with Programs 8(6):957-958.

Knebel, H.J. and E. Spiker. 1977. Thickness and age of the surficial sand sheet, Baltimore Canyon Trough area. American Association of Petroleum Geologists Bulletin 61:861-871.

Knebel, H.J. and D.C. Twichell. 1978. Heavy-mineral variability in the Baltimore Canyon Trough area. Journal of Research of the U.S. Geological Survey 6:215-219.

Mattick, R.E., D.W. Folger, N.T. Foley, G.H. Dolton, and K.C. Bayer. 1976. Summary report of the sediments, structural framework, petroleum potential, environmental conditions, geotechnical considerations of the United States Mid-Atlantic continental shelf. U.S. Geological Survey Open File Report 76-532, 26 p., 4 figs.

Miller, R.E. and D.M. Schultz. 1977. Hydrocarbons in surface sediments of Mid-Atlantic continental shelf region--initial survey (abs.). American Association of Petroleum Geologists Bulletin 61(5):814-815.

Sheridan, R.E. and H.J. Knebel. 1976. Evidence for post-Pleistocene faults of the New Jersey Atlantic Outer Continental Shelf. American Association of Petroleum Geologists Bulletin 60:1112-1117.

Twichell, D.C., H.J. Knebel, and D.W. Folger. 1977. Delaware River: Evidence for its former extension to Wilmington Submarine Canyon. Science 195:483-485.

Other Related Contracts Within This Study Program:

- MU0-16/29175
- MU0-18/29175
- IA1-15/29183
- IA1-17/29184
- IA2-26/29196
- CT6-62 & MU7-31
- MU9-08/29166
- MU6-29
- MU6-56
- MU8-13
- MU8-21
- MU8-24
- MU9-04

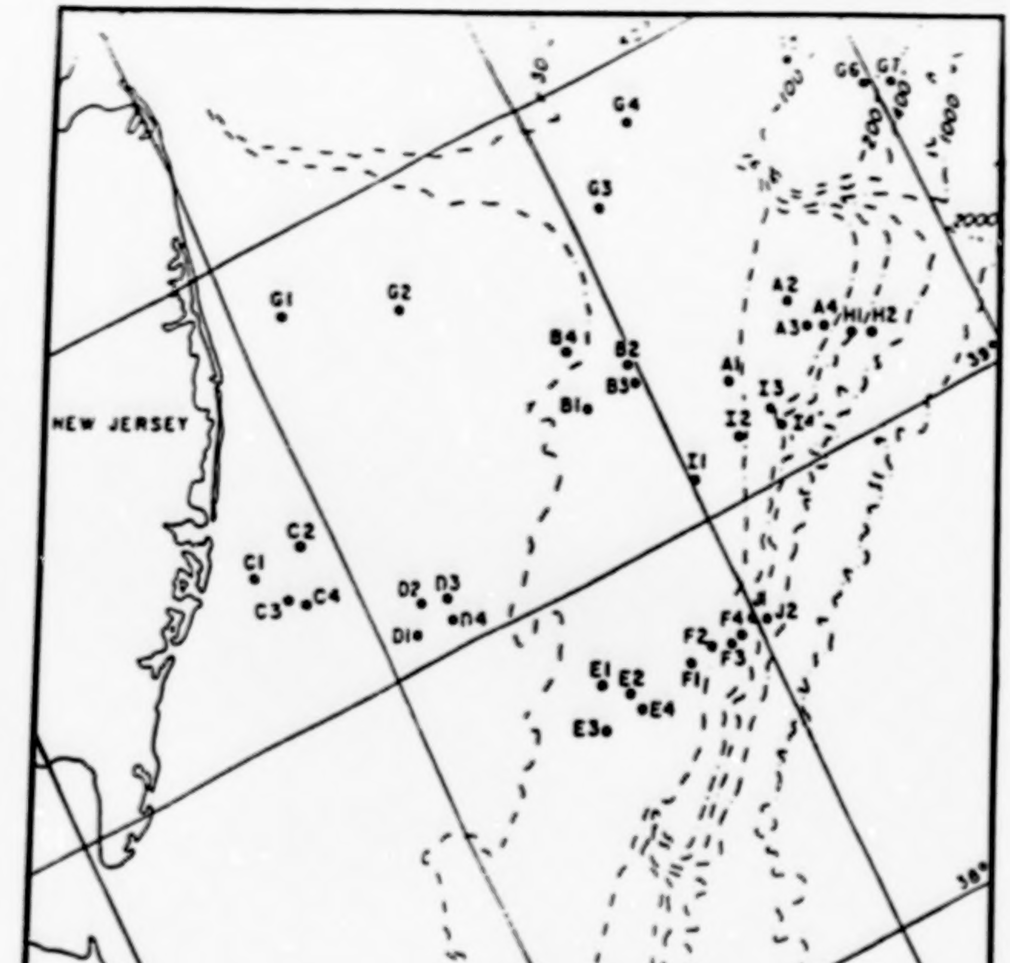

Figure 15. Mid-Atlantic stations sampled for macrobenthos. (Source: BLM Contract No. AA550-CT5-42).

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BLM CONTRACT NO.: AA550-CT6-62 (VIMS)
MMS CONTRACT NO. 14-12-0001-29129
BLM INTERAGENCY AGREEMENT NO.: AA550-MU7-31 (USGS)

Title: Environmental Data Acquisition Analysis--Mid-Atlantic OCS, Year 2

Date: 30 September 1976 - 22 February 1980 (CT6-62)
26 July 1977 - 24 October 1978 (MU7-31)

Cost: $3,629,823 (CT6-62)
$ 994,730 (MU7-31)
$4,624,553

Prime Contractor:
Virginia Institute of Marine Science (VIMS)
Gloucester Point, Virginia 23062
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
American University (AU)
University of Delaware (UD)
University of Virginia (UV)

Chartered Research Vessels:
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Program Manager:
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Eugene M. Burreson (VIMS)
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J. Musick
W. Roller
G. Ruddell
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R. Wetzel

Contracting Officer:
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F.M. Galinsky
Carroll D. Day

COTR: Arthur J. Horowitz
Philip Thomas

Key Words:
benthic studies; geology-general treatment; hazards-geologic sediment characteristics

Objectives:
The objectives of the second year field studies conducted by VIMS were to:

1. Collect and analyze chemical and biological data on conditions existing prior to oil and gas development.
2. Assess the processes regulating biological communities.
3. Determine levels of chemical constituents in the shelf environments.

The second year study by U.S. Geological Survey was a continuation of the first year's work (summaries for AA550-CT5-42 and 08550-MU5-33). General objectives were to:

1. Measure the rate of sediment mobility over the seabed and monitor resultant changes in bottom concentrations.
2. Evaluate the geotechnical properties of bottom and subbottom sediments and their potential hazard to oil and gas development.
3. Determine the concentration, distribution, and flux of suspended particulate matter in the water column.
4. Determine the nature and distribution of high molecular weight hydrocarbons in the near-surface sediments at selected locations.

Summary:
The second year study by Virginia Institute of Marine Science was a continuation of the first year's work. New tasks were initiated which focused on the processes controlling benthic communities and finfish distributions. The report synthesized the data from both years of sampling. The results of both years can be summarized: 1) the Mid-Atlantic waters were characterized by three water masses (coastal boundary layer, shelf water and slope water); 2) eggs and larvae of fishes and crustaceans were abundant in the spring neuston collections; 3) macrobenthos demonstrated little seasonality and were most dense on the outer shelf; 4) local ridge and swale topography strongly influenced the distributions of sediments, chemical constituents in the sediments, and the benthic biota; 5) predation by demersal fish and epibenthic invertebrates is one factor which controls population levels of certain benthic species; and 6) local ridge swale topography had little effect on the distribution of highly mobile demersal fishes. Warmer water was present below the cold water. Three distinct subsurface zooplankton communities were present across the shelf: a coastal community, a central-outer shelf community, and a shelf-edge/slope community. Neuston collections

revealed a predictable coastal assemblage and an unpredictable shelf edge community. The surface layer was important to juveniles and larvae of many fish and invertebrate species. Meroplankton abundance decreased across the shelf in a seaward direction. Dissolved aliphatic hydrocarbon concentrations ranged from 0.004 to 114 ug l^{-1}; dissolved aromatic hydrocarbons ranged from 0.012 to 259 ug l^{-1}. No seasonal trends were evident. Particulate aliphatic hydrocarbon concentrations ranged from 0.0001 to 1.88 ug l^{-1}; particulate aromatic hydrocarbons ranged from 0.001 to 0.02 ug l^{-1}. Some seasonality was noted. In zooplankton, aliphatic hydrocarbons ranged from 2.0 to 3,218 ug g-1 and aromatic hydrocarbons from 2.2 to 650 ug g^{-1}. Bacteria in the microlayer were not enriched relative to subsurface samples. Trace metals concentrations in the water column were generally highest in the coastal boundary layer and decreased seaward across the shelf. Barium and vanadium concentrations were low. Cadmium, lead, and zinc were found mainly in the leachable fraction, while chromium and iron were unleachable. Trace metal levels in zooplankton were highly variable with no definite spatial or temporal trends evident.

Sediment texture and distribution took the form of swales and ridges. Most shelf sediments are medium to coarse sand with fine muds typifying the shelf break and slope. Organic carbon was closely related to the distribution of silt/clay. Sediment trace metal concentrations (leachable and total) increased seaward across the shelf and were greater in topographic depressions. No seasonal trends were observed in trace metals levels. Sediment levels of aliphatic and aromatic hydrocarbons also increased seaward across the shelf.

Foraminiferal density ranged from 10 to 5,500 organisms per 20 cm^3. Foraminifera were roughly classified into inner and central shelf zone, an outer shelf zone, and a shelf break zone. Meiofaunal densities ranged from 59 to 1,123 organisms per 10 cm^3. Nematodes numerically dominated the meiofauna, comprising 40 to 80 per cent of the individuals collected. Harpacticoid copepods were the second most abundant organism, representing 5 to 30 per cent of the individuals collected. Polychaetes constituted 40 to 60 per cent of the macrobenthic individuals. Other groups included amphipods, echinoderms, and mollusks. Megabenthos collected by dredge and trawl was numerically dominated by decapod crustaceans, echinoderms, and bivalve mollusks. Species diversity of both macrobenthos and megabenthos generally increased with depth. Minor faunal differences in both macrobenthos and megabenthos occurred over small distances within the broad scale patterns in relation to shelf topography. Demersal fishes collected by trawl included three migratory groups based on seasonal distribution. Temperature and depth were the most important factors controlling the distribution of fishes on the shelf. Stomach content analyses indicated that demersal fishes prey mainly on benthic invertebrates, but not necessarily the most abundant species. Trace metals concentrations in the benthos were quite variable. Some evidence of sediment contamination was found, particularly in sand dollars. Hydrocarbon levels in benthic organisms were low, with no evidence of petroleum contamination.

Bottom current conditions were relatively calm during spring and summer months. Net bottom flow on the continental shelf was toward the southwest. Small-scale bed forms rapidly formed in response to wind-driven flow during large storms. Total suspended particulates in surface and near-bottom waters were highest during spring months. Bottom sediments on the OCS were resuspended periodically, possibly by internal waves. The clayey sediments tested were heavily over consolidated, with adequate shearing resistance and low compressibility, presenting no unusual hazard to facility siting.

The second year of study by the USGS can be summarized as follows:

Cross-shelf trends in biological, physical, geological, and chemical parameters were evident in both the pelagic and benthic realms. Many environmental factors covary with depth across the shelf in a seaward direction, and these factors were responsible for observed biological or chemical trends. Sediments were generally stable with respect to potential structure siting. No evidence of petroleum contamination was found in benthic organisms.

Geologic environmental hazards in the area do not warrant withdrawal of lease tracts, or preclude petroleum exploration or development on the shelf. The probability of structural failures will be greater during major winter storms or hurricanes. Recommended studies include continuing observations of currents and bottom conditions, assessing the kinds and amounts of suspended matter in the water column, determining the rates and depths of bottom sediment mixing, and identification and mapping of slumping and potential slump hazards on the upper continental slope.

FINAL REPORT:

Middle Atlantic Outer Continental Shelf environmental studies - second year. (USGS; 1979).

AVAILABILITY:

Available from NTIS:

- Executive Summary (Vol. I) - PB81-174740
- Final Report (Vol. IIA, Chemistry & Biology) - PB81-174757
- Final Report (Vol. IIB, Chemistry & Biology) - PB81-174765
- Final Report (Vol. IIC, Chemistry & Biology) - PB81-174773
- Final Report (Vol. IID, Chemistry & Biology) - PB81-174781
- Final Report (Vol. III, Geology) - PB81-174799

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Hosom, D.S., and K.W. Doherty. 1979. A water sampling system for a long deployment monitoring system. Woods Hole Oceanographic Institution Technical Memorandum No. 4-79, 140 p.

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Knebel, H.J. 1978. Geologic conditions in the Baltimore Canyon Trough area: A summary of USGS second year environmental studies. U.S. Geological Survey Open File Report 78-921, 33 p.

____________. 1981a. Processes controlling the characteristics of the surficial sand sheet, U.S. Atlantic Outer Continental Shelf. Marine Geology 42:349-368.

____________. 1981b. Processes controlling the characteristics of the surficial sand sheet, U.S. Atlantic Outer Continental Shelf, In: Sedimentary dynamics of continental shelves. C.A. Nittrouer (ed.). Developments in Sedimentology 32, Amsterdam: Elsevier, pp. 349-368.

Kornicker, L.S. 1978. *Harbansus*, a new genus of marine Ostracoda, and a revision of the Philomedidae (Myodocopina). Smithsonian Contributions to Zoology. 260, 75 p.

LaGatta, D.P., K. Dalenberg, H.J. Knebel, and D.A. Sangrey. 1978. Report on laboratory testing of shallow sediments of Middle Atlantic Outer Continental Shelf. U.S. Geological Survey Open File Report 78-578, 249 p.

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Smyth, P.O., n.d. *Callinectes* larvae in surface and subsurface collections in the Middle Atlantic Bight, 1975-1977. NOAA Fisheries Bulletin In press.

Vecchione, M. 1978. Larval development of *Illex* Steenstrup, 1880, in the northwestern Atlantic with comments on *Illex* larval distributions. Proceedings of the Biological Society of Washington. 91:1060-1075.

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Other Related Contracts Within This Study Program:

- MU0-16/29175
- MU0-18/29175
- IA1-15/29183
- IA1-17/29184
- IA2-26/29196
- CT5-42 & MU5-33
- MU6-29
- MU6-56
- MU8-13
- MU8-21
- MU8-24
- MU9-04
- MU9-08/29166

Environmental Studies Index

Mid-Atlantic

Socio-economics

120

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BLM CONTRACT NO.: CT6-01

Title: Evaluation of Regional Economic Effects of Offshore Oil and Gas Production in Mid-Atlantic OCS - Harris Model

Date: August 1975 - 1976

Cost: $2,500

Prime Contractor:

International Research and Technology Corporation (IRT)
McLean, Virginia 22102

Objectives:

The objective of this study was to determine the environmental impact of onshore activity from offshore oil and gas development in four New Jersey coastal counties.

Summary:

Results of this study were as follows:

1. Sulfur oxide emission could increase to a level producing a significant deterioration of air quality if stringent sulfur removal controls are not placed on gas processing plants. Other air emissions are not likely to increase enough to warrant serious concern.
2. Point source water emissions are not likely to increase significantly as a result of the onshore impact of offshore drilling.
3. Run-off from construction may be significant. More information is needed to evaluate this impact.

The Strategic Environmental Assessment System and Harris models were extremely useful in providing the basis for performing this environmental assessment. However, other source materials and careful analyses were required to provide meaningful interpretation of the results of the models.

Final Report:

Environmental consequences of onshore activity in four New Jersey coastal counties resulting from offshore oil development. (M.N. Kramer, S. Ratick, A. Watson; 1975).

Availability:

Available from NTIS:
Final Report - PB249349

BLM CONTRACT NO.: **AA851-CT2-25**
MMS CONTRACT NO.: **14-12-0001-29195**

Title: Environmental Impacts of Utilizing Pipeline Corridors in the Mid-Atlantic

Date: 9 April 1982 - 20 December 1983

Cost: $150,000

Prime Contractor:
Policy Planning & Evaluation, Inc. (PPE)
8301 Greensboro Drive, Suite 460
McLean, Virginia 22102

Subcontractors/Cooperating Institutions:
Center for Coastal and Environmental Studies of Rutgers University (CCES)

Program Manager:
James Brosius

Principal Participants:
Norbert Psuty
Christopher Talbut

Contracting Officer:
Jeffrey P. Petrino

COTR: Neville Chow

Key Words:
pipelines; oil and gas; hazards-geologic sediment characteristics; effects-ecological; effects-socio/economic; literature search (bibliography)

Objectives:

1. Compile information on the potential hazards of pipeline emplacement in the Mid-Atlantic on the biological and cultural resources in the region.

2. Develop maps of these hazards and resources depicting their spatial and temporal location, including a composite map depicting the relative risk to pipeline emplacement within discrete areas.

3. Document data sources for the maps, and provide supporting text assessing relative hazards/impacts of specific factors or regions to pipeline emplacement and suggesting measures to eliminate or alleviate these hazards/impacts.

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Summary:

This study was designed to identify and assess the range and magnitude of potential impacts associated with the construction and operation of submarine pipelines in the Outer Continental Shelf (OCS) of the Mid-Atlantic Region. The study will be used in the pipeline-siting process, and will serve as a source document for the Minerals Management Service in pre- and post lease sale decision making.

In order to ensure that pipelines are constructed in a safe manner, and designed to operate safely over their projected lifetime with minimal disruption of the marine environment, it was necessary to assess the suitability of areas for pipeline construction. This assessment was accomplished by characterizing and inventorying the geologic, biologic, and cultural/economic features of the Mid-Atlantic OCS where pipelines might be sited. The characterization was followed by an investigation of potential impacts associated with pipeline construction and operation, based on experiences in other areas.

Finally, an assessment of the probable impacts associated with the specific features of the Mid-Atlantic OCS was undertaken, and was given a value of HIGH, MODERATE, LOW, or SPECIAL CASE reflecting the impact potential associated with it.

It was found that relatively few HIGH impact areas exist in the study area, but a number of mitigating measures and special practices are needed to minimize impacts which may occur in other areas. Specific areas which should be avoided include certain dumpsites, a marine sanctuary, an area of surf clams off Atlantic City, New Jersey, and canyons and canyon heads. In the remaining areas, the adoption of special stipulations involving the engineering and design of the pipeline, and the coordination of activities between the pipeline industry and other resource users, in addition to standard industry procedures, are required to ensure safe development and operation of the pipeline.

This report is based on the best available knowledge describing pipeline impacts in other areas. Therefore, the findings of the study are limited by the problem of applying information from one geographic area to activities in another. Further, the report describes impacts associated with one pipeline, and does not reflect the cumulative impacts which might result from several pipelines.

Final Report:

Identification and assessment of impacts associated with the construction and operation of submarine pipelines on the Mid-Atlantic Outer Continental Shelf. (J.E. Brosius, C.W. Talbot, N.P. Psuty; 1983).

Availability:

Available from NTIS:
Final Report - PB84-187863

Mid-Atlantic

Geology and Chemistry

BLM INTERAGENCY AGREEMENT NO.: AA551-MU8-21

Title: Mid-Atlantic Geologic Studies, Year 3

Date: 16 June 1978 - 15 May 1979

Cost: $848,898

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)

Chartered Research Vessels:
R/V Atlantis II
R/V Columbus Iselin
R/V Endeavor
R/V Gillis
R/V Gyre
R/V Oceanus

Program Manager:
James M. Robb

Principal Participants:
James S. Booth
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R.E. Miller
John A. Moody
James M. Robb
Richard A. Slater

Contracting Officer:
Paul Lubetkin
Carroll D. Day

COTR: Arthur Horowitz
Eiji Imamura

Key Words:
Georges Bank study; hazards-geologic sediment characteristics; sediments (geology); transport-sediments

Objectives:

1. Estimate the extent and rate of sediment mobility over the seabed and monitor resultant changes in bottom morphology and texture.

2. Identify major processes causing sediment movement and assess seasonal variability.

3. Complete a study of suspended particulate matter in the water column that was begun under a previous Memorandum of Understanding.

4. Determine the rates and depths of sediment mixing in Sale 40 and Sale 49 lease areas as an aid to predicting the fate of spilled hydrocarbons, drilling chemicals, and drill cuttings.

5. Identify and map areas of slumping or of potential slumping hazards in lease areas on the continental slope.

6. Identify and study the effects of processes and mechanisms contributing to sediment instability in offshore lease areas which may lead to the inception of slumping and sliding.

7. Assess the geotechnical properties of sediments in the continental slope lease areas.

8. Determine potential geologic hazards in nearshore areas.

Summary:
This and previous studies under BLM/USGS agreements were directed toward characterization of the environments of the Outer Continental Shelf (OCS) - measurements of day-to-day activity of the sea waters and descriptions of those aspects of the sea floor which can tell us what processes have taken place to create and modify it.

Material on the bottom at continental shelf depths is stirred up by storms from time to time. Tidal motions are commonly the strongest components of coastal sea-water motions and cause rotary currents, whose velocity vectors trace out ellipses over diurnal periods. On Georges Bank, where tidal currents are strongest southeast and northwest in the onshore and offshore directions, there is a long-term component of water transport toward the southwest. This transport apparently leads to the deposition in the "mud patch," an area south of Martha's Vineyard, of fine-grained material winnowed from Georges Bank. If fine-grained materials are produced by drilling activities, the "mud patch" may be the site of their eventual accumulation. The amount of material carried southwest from the "mud patch" to the Mid-Atlantic shelf is probably slight but is not determined.

Near Wilmington Canyon, on the southern part of the area of greatest exploration interest in the Mid-Atlantic OCS, Gulf Stream rings (eddies shed from the northeast-flowing Gulf Stream) affect the currents of the outer shelf. The major factor affecting flow in that area is wind stress. In the deeper waters seaward of the continental shelf break, bottom currents caused by wind stress are much reduced.

Residence times of material suspended near the bottom in a nepheloid layer (turbid near-bottom waters) were found to be about 5 hours on

Georges Bank, 1.3 days in the "mud patch" south of Martha's Vineyard, and 2 days in the Mid-Atlantic Bight region. Such values are low compared to residence times of 1 to 3 months for deep-sea nepheloid layers, and emphasize the relatively dynamic environment of the continental shelf area. Once material is deposited on the sea bottom, radioisotope studies (^{210}Pb) show that it may be mixed in to a depth of 20 cm within a relatively short time (less than 20 years) by biological activity as well as by wave and current agitation.

On the inner continental shelf, a buried valley formerly occupied by the Hudson River was found to extend southward across the shelf from the New York area. Other buried valleys have been found running across the shelf from Delaware Bay and from the Toms River, but the existence of this ancient valley of the Hudson had been previously unknown. Its presence and the sediments transported through it may help to explain the sites and configurations of some submarine canyons along the continental slope, as well as the nature of a slightly shallower area along the southern bank of the present Hudson Channel on the continental shelf. The buried valley was found to be filled with interbedded sands and muds. Geotechnical tests of the overlying material show that is should not cause problems of stability for future engineering efforts.

Studies on the continental slope were primarily directed to determining its stability. Studies using seismic profiles, cores, and submersible dives showed that the slope has a very complex bathymetric surface which has probably remained largely unchanged since, the ice age; there were few slump or landslide features found. However, small-scale (1-2 m) slides probably occurred from time to time on some of the steeper slopes, and geotechnical tests did show that some places may be marginally stable. The channel ways and lower walls of submarine canyons should probably be viewed with caution as sites for semipermanent structures.

Seismic-reflection profiles along the upper continental slope commonly show "turbid zones" or "washouts" attributed to the presence of gas in the sediments. Studies to determine whether gas in the interstices of the sediment could have an effect on stability were largely inconclusive because of necessarily crude sampling techniques and our inability to determine in-situ pressures and quantities of gas. However, those analyses did show the presence of considerable amounts of hydrocarbon gases in some places, and that some of those gases may by thermogenic, related to deep-seated petroleum deposits in the area.

Final Report:

Environmental geologic studies in the Mid-Atlantic Outer Continental Shelf area--results of 1978-1979 field seasons. (J.M. Robb, ed.; 1982).

Availability:

Available from NTIS:

Final Report and Executive Summary - PB83-147934

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_______________. 1979. Geologic conditions in the Baltimore Canyon Trough area: A summary of USGS first-year environmental studies. U.S. Geological Survey Open File Report 79-1552, 26 p.

Folger, D.W., H.J. Knebel, and D.C. Twichell. 1976. Ancestral Delaware River Valley: Evidence for cross shelf extension to Wilmington Submarine Canyon (abs.). Geological Society of America, Abstracts with Programs 8(29):175-176.

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Knebel, H.J. 1978. Geological conditions in the Baltimore Canyon Trough area: A summary of USGS second-year environmental studies. U.S. Geological Survey Open File Report 78-921, 33 p.

_______________. 1979. Anomalous topography on the continental shelf around Hudson Canyon. Marine Geology 33:M67-M75.

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McGregor, B.A. 1981. Ancestral head of Wilmington Canyon. Geology 9:254-257. Mattick, R.E., D.W. Folger, N.T. Foley, G.H. Dolton, and K.C. Bayer. 1976. Summary report of the sediments, structural framework, petroleum potential, environmental conditions, geotechnical considerations of the United States Mid-Atlantic continental shelf. U.S. Geological Survey Open File Report 76-532, 26 p., 4 figs.

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Poag, C.W., H.J. Knebel, and R.E. Todd. 1980. Distribution of modern benthic foraminifers on the New Jersey Outer Continental Shelf: Marine Micropaleontology 5:43-69.

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Robb, J.M., J.C. Hampson, Jr., and D.C. Twichell. 1981. Geomorphology and sediment stability of a segment of the U.S. Continental Slope off New Jersey. Science 211:935-937.

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Scanlon, K.M. GLORIA sidescan and seismic data collected by the DESV Starella along the continental slope and upper continental rise of the eastern United States in 1979. U.S. Geological Survey Open File Report 82-1095. 3 p.

Schlee, J.S., R.E. Mattick, R.B. Powers, J.M. Robb, D.C. Twichell, and B. Butman. 1979. Summary report of the sediments, structural framework, petroleum potential, and environmental conditions of the United States Mid-Atlantic continental margin in area of proposed Oil and Gas Lease Sale No. 59. U.S. Geological Survey Open File Report 79-1351.

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_____________. 1979. Small scale slump deposits, Middle Atlantic continental slope off eastern United States. Marine Geology 29:221-236.

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Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
MU9-08/29166
CT6-62 & MU7-31
MU6-29
MU6-56
MU8-13
MU8-24
MU9-04

Environmental Studies Index

Mid-Atlantic

Physical Oceanography

BLM INTERAGENCY AGREEMENT NO.: AA550-IA6-12

Title: Mid-Atlantic Physical Oceanographic and Meteorological Study

Date: October 1977

Cost: $128,000

Prime Contractor:
National Oceanic and Atmospheric Administration (NOAA)
Environmental Data Service
Center for Experiment Design and Data Analysis

Program Manager:
Eugene M. Rasmusson

Principal Participants:
Robert G. Williams
Fredic A. Godshall

Key Words:
circulation/current study; meteorology; hydrographic, salinity, temperature data; historic review; wind data/studies

Objectives:

1. To summarize historical meteorological and oceanographic data for the region.
2. To analyze the historical data summaries.
3. To draw conclusions from the analysis and to recommend design for future field programs to fill existing data gaps.

Summary:
The surface wind field, which affects the movement of spilled pollutants, as analyzed on the basis of passing-ship, of "Marine Deck," observations is similar to that documented in the literature. The Marine Deck observations are quite adequate for defining major statistical features of the surface wind field, but better estimates of extreme wind speeds and return periods depend on many more years of wind records or an improved statistical estimation method. Water masses, whose structure and variability are particularly relevant to the dispersion and advection of pollutants, were analyzed. In winter, water temperatures on the shelf are nearly uniform, at 5 to 7°C with a slight increase with depth. Warming begins in late March to April, leading to a weakening of horizontal gradients and the development of a seasonal thermocline, usually located at a depth of 15 to 25 m. Summer water still persists. Salinity increases seaward, is highest in winter, and increases with depth in all seasons. Dissolved oxygen concentrations vary seasonally, with the water in the surface layer always being saturated and large vertical differences being found in the mid-shelf area. Surface currents, which act directly to advect

and disperse pollutants, were analyzed from ship-drift data, and current vectors and variability statistics were computed. Seasonal variability was found to be not as pronounced as variability reported in the literature from surface-drifter studies. Vertical mixing is strong in winter, when nearly homogenous water is found from the surface to the bottom. The seasonal wave climatology compiled from visual shipboard observations shows that sea states in the Mid-Atlantic region are maximum in winter and minimum in summer.

Final Report:

Summarization and interpretation of historical physical oceanographic and meteorological information for the Mid-Atlantic region. (NOAA; 1977).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS:
PB277104/AS

MMS CONTRACT NO. 14-12-0001-30066

Title: Mid-Atlantic Slope and Rise Study (MASARS) - Physical Processes

Date: 9 September 1983 - September 1986

Cost: $2,764,638

Prime Contractor:
Science Applications, International Corporation (SAIC)
Admiral's Gate
221 Third Street
Newport, Rhode Island 02840-6669

Subcontractors/Cooperating Institutions:
Shell Oil Company
U.S. Environmental Protection Agency (EPA)
University of Maryland (UMD)
University of Miami (UM)
University of North Carolina (UNC)
University of Rhode Island (URI)
Woods Hole Oceanographic Institute (WHOI)

Chartered Research Vessels:
R/V Cape Henlopen
R/V Regent Seahorse

Program Manager:
Mr. Christian Casagrande

Principal Participants:
John Bane (UNC)
William Boicourt (UMD)
Otis Brown (UM)
Gabriel Csanady (WHOI)
Robert Evans (UM)
Peter Hamilton (SAIC)
Donald Olson (UM)
Randolph Watts (URI)

Advisory Board:
Glenn Flierl
Christopher Garret
John Walsh

Contracting Officer:
Jeffrey P. Petrino

COTR: James Lane
William H. Lang

Key Words:
circulation/current study; remote sensing, aerial, satellite; transport (physical processes)

Objectives:

1. Determine broad-scale, general circulation features on the continental slope and rise on a seasonal basis.

2. Describe and quantify the variability in these areas in the vertical and horizontal plane.

3. Determine the degree to which the slope/rise circulation features influence the physical oceanography of the Middle Atlantic continental shelf.

4. Determine local currents and sediment distribution around the Block 372 deep-water drillsite.

Summary:

Initially, the MASAR mooring array was located along two transects; the northern transect off New Jersey consisting of five moorings and the southern transect off Virginia consisting of three moorings. Six months later, the EPA low-level radioactive disposal site mooring data were added to the MASAR data base. During the final six months of field effort, the MASAR array was expanded to include eight additional moorings; four placed along the 2000 m isobath between the northern and southern transects in order to provide smaller scale definition of circulation, two moorings on the shelf to tie in with MECCAS, and two additional moorings off Cape Hatteras to provide data on Gulf Stream frontal excursions.

The general circulation and exchange processes over the shelf edge, slope, and rise appear to be affected by repeated and drastic changes in the Gulf Stream position off Cape Hatteras. These changes were initially considered anomalous; however, they persisted during most of the study period. The historical mean path of the Gulf Stream follows a relatively straight northeast track downstream from Cape Hatteras. However, during approximately 75 per cent of the two-year MASAR field effort, the Gulf Stream path followed a more northerly course. The northern position would remain relatively stable for long periods before changing back to the historical or so called normal position. Data from satellite imagery and from the Watts/Bane Gulf Stream Meander program suggest that the interaction of cold core rings or warm core rings can trigger the Gulf Stream position change. The actual change takes place over a few days to a week.

The exchange processes across the shelf/slope front can be summarized as follows:

Submesoscale eddies are active at the shelf break, regardless of the anticyclonic warm core rings affecting the slope sea. Eddies with diameters of 30-50 km and velocities of 30-50 cm s^{-1} are evident in the daily averaged current measurements over the outer shelf when winds are weak.

Direct Gulf Stream entrainment of shelf water can occur as far north as Delaware Bay when the Gulf Stream is in its northern position. Many of the shelfwater filaments appear to have a 40 m thick surface layer, a second 8°C layer from the cold pool on the outer shelf, and a third layer having the characteristics of the slopewater pycnostad.

There appears to be a seasonality to the shelf-slope exchange, such that the shelf-slope front is more conducive to cross-frontal transfer in summer than in winter.

Caballing (mixing of two parent water masses resulting in a slightly higher density mass which then proceeds to sink) appears to be an active mode of exchange at the shelf break accounting for shelfwater existing at depths considerably greater than 200 m.

Mesoscale (anticyclonic) and submesoscale (both anticylonic and cyclonic) eddies are more effective in driving intrusions of slope water onto the shelf, along the bottom, than previously thought. Existing data have documented at least fifteen intrusions onto the shelf, all of which were either shoreward of a warm core ring or within 40 km in the alongshelf direction of a warm core ring.

Horizontal isopycnals, resulting from the compensatory effects of T-S gradients on density, seem to favor wind-driven cross-isobath currents near the surface (mostly a summer phenomenon).

Ekman-induced surface flow towards the east appears to be compensated by intrusions of higher salinity slopewater at mid-depth. Some 5 to 10 m thick intrusions have penetrated 60 km shoreward of the shelf-break.

The multitude of mechanisms governing the shelf-break has prevented and integrated, quantitative estimate of exchange to date.

Final Report:

Mid-Atlantic slope and rise physical oceanography study, first and second year semi-annual reports. (SAIC; 1984).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Available from NTIS:
Vol. I PB 87-200515/AS
Vol. II PB 87-200523/AS
Vol. III PB 87-200531/AS
Set PB 87-200507/AS

Other Publications/Reports:

Csanady, G.T., J. Churchill, and B. Butman. 1988. Near-bottom currents over the continental slope in the Mid-Atlantic Bight. Continental Shelf Research 8(5-7):653-671. Woods Hole Oceanographic Contribution No. 6316, pp. 653-671.

Csanady, G.T. 1988a. Circulation of slopewater. Continental Shelf Research 8(5-7):565-624.

_______________. 1988b. Radiation of topographic waves from Gulf Stream meanders. Continental Shelf Research 8(5-7):673-686.

Hamilton, P. 1985. Slope Currents in the southern Mid-Atlantic Bight: Preliminary results from the MASAR experiment. EOS: Transactions, American Geophysical Union (Abs.) 66:282.

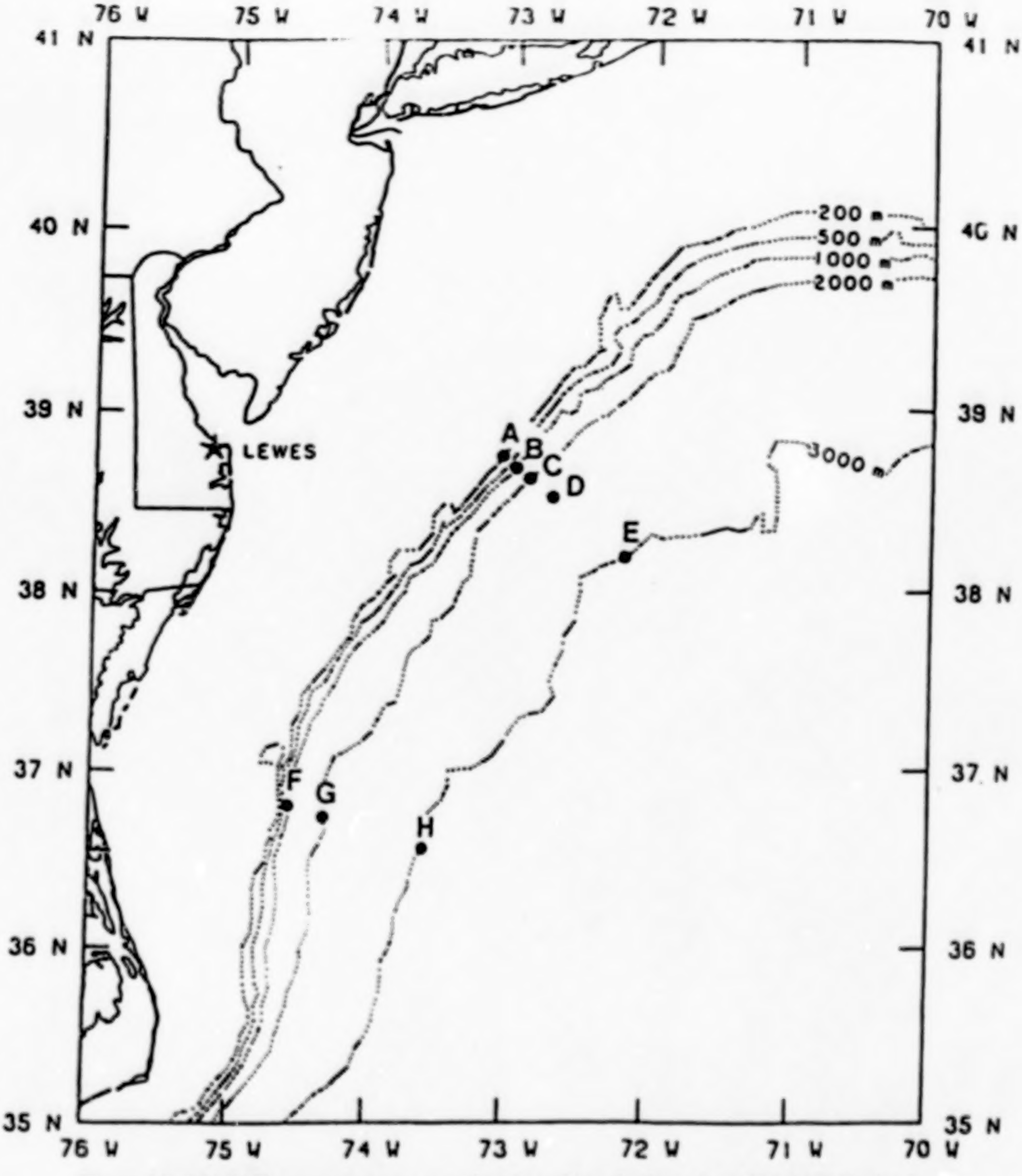

Figure 16. MASAR current meter mooring locations deployed on MASAR Cruise I, 24 February – 4 March, 1984 (R/V Cape Henlopen Cruise CH-84-11). (Source: MMS Contract No. 14-12-0001-30066).

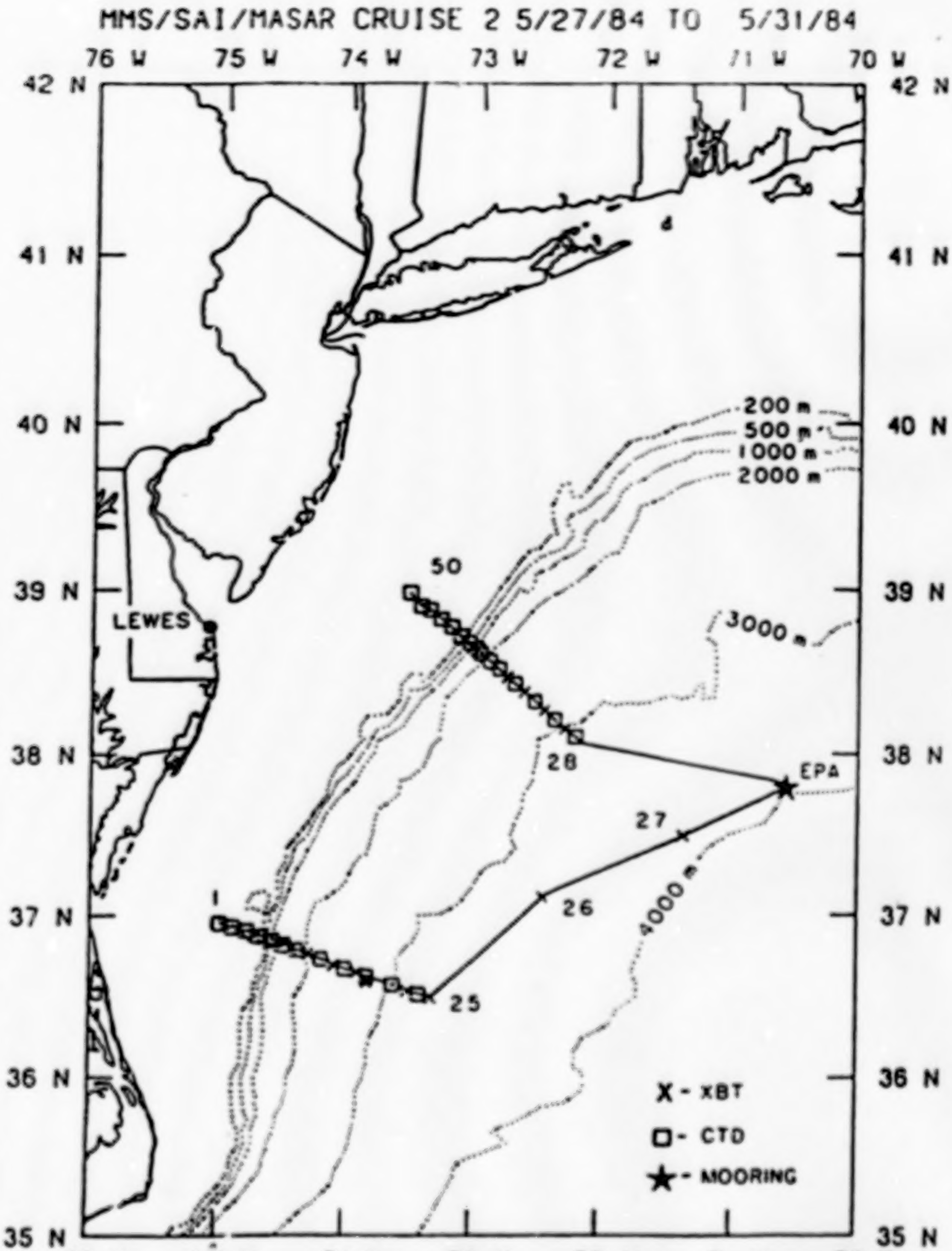

Figure 17. MASAR XBT and CTD stations sampled at 3 – month intervals from February, 1984 to February, 1986; and the EPA mooring site during MASAR Cruise II, May 1984. (Source: MMS Contract No. 14-12-0001-30066).

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MMS CONTRACT NO.: 14-12-0001-30152

Title: Analysis of Physical Oceanography Data Offshore North Carolina

Date: March 1984- May 1984

Cost: $19,250

Prime Contractor:
Research Triangle Institute (RTI)
Research Triangle Park
North Carolina 27709

Program Manager:
F. Vukovich

Principal Participants:
B. Crissman
G. Janowitz
L. Pietrafesa
F. Vukovich
R. Weisberg

Contracting Officer:
Jeffrey Petrino

COTR: Robert La Belle
David Amstutz

Key Words:
current measurements, meters, drifters; oil sill model; oil transport; meteorology

Objectives:

1. To examine currents offshore of North Carolina related to wind driven and Gulf Stream frontal event effects from existing data sets.
2. To examine relationships of these factors to oil spill risk assessment and potential differences between actually existing flow fields and those predicted by the MMS Oil Spill Risk Model.

Summary:
Moored current meter, satellite very high resolution radiometer, satellite synthetic aperture radar, hydrographic, coastal zone color scanner and surface drifter data sets were collected for the period 15 March to 4 May 1979. The data sets were analyzed to determine potential effects of wind induced currents and/or Gulf Stream frontal events on North Carolina offshore currents. The report includes discussions and correlations of nearshore and offshore currents and penetration of Virginia coastal waters south of Cape Hatteras. The case study examined currents offshore of North Carolina when a series

of waveforms existed on the western Gulf stream boundary, in the region between 31 to 36° N Lat. and 74 to 80° W Long. (southeast of Raleigh and Onslow Bays, NC), during the period 15 March to 4 May 1979. These factors were examined in relation to oil spill risk assessment and potential differences between flow fields that actually exist and those predicted by the MMS OSRA Model.

Near surface currents off the North Carolina coast are affected by: (1) direct wind forcing; (2) interior currents (slope currents) set up by convergence of wind driven current due to the presence of lateral boundaries; and (3) existing background currents (i.e., the Gulf Stream). Present MMS modeling efforts attempt to account for direct wind driven currents and background currents but do not consider slope currents. Slope currents reflect the past history of alongshore wind stress components and add directly with direct wind driven currents at the sea surface.

Dynamical nearshore current regimes in Onslow Bay, North Carolina fall into two classes: (1) inshore of the 50 m isobath strongly correlated to and dominated by wind; and (2) offshore of the 75 m isobath, at 17 m depth, resulting from Gulf Stream phenomena (i.e., filament formation, meandering, and wave propagation) along the front.

For the period 2 to 9 April, MMS predictions were on the same order of the observed net displacement of a parcel of water. Differences between direct wind driven current (as modeled by the MMS using Cape Hatteras wind data) and combined wind driven and slope currents occurred between 12 to 16 April, both in magnitude and direction for net displacement of a parcel. Observations placed the parcel on the coast, while MMS predictions placed the parcel in deeper water. The conclusion is that proper incorporation of time varying slope currents into modeling of parcel trajectories is imperative to obtain realistic risk analysis.

Apart from wind driven currents, the Gulf Stream provides background currents off the North Carolina coast. Gulf Stream frontal events provide omnipresent initialization of offshore, time varying boundary. Frontal filaments and growing meanders, with time scales of several days to two weeks, provide a mechanism to bring offshore waters onshore. Because they are dominant coastal features, initial conditions for movement of an oil spill will be provided by these features which can advect enormous amounts of water and contaminants onshore to the coast.

Final Report:

Effects of wind and Gulf Stream events on the currents off the coast of North Carolina as it relates to oil spill risk potential. (RTI; 1984).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Available from NTIS: PB89-219430/AS

MMS CONTRACT NO.: **14-12-0001-30349**

Title: Gulf Stream Frontal Dynamics Study Offshore North Carolina

Date: March 1987 - May 1989

Cost: $719,312

Prime Contractor:
Evans-Hamilton, Inc. (EH)
Western Region
731 N. Northlake Way, Suite 201
Seattle, Washington 98103

Subcontractors/Cooperating Institutions:
Old Dominion University (ODU)
University of North Carolina (UNC)
Texas A & M University (TAMU)
University of Miami (UM)
Research Triangle Institute (RTI)
Harvard University (HU)
Science Applications International Corporation (SAIC)
Office of Naval Research (ONR)

Program Manager:
Curtis C. Ebbesmeyer

Principal Participants:
Larry P. Atkinson (ODU)
John M. Bane (UNC)
David A. Brooks (TAMU)
Otis B. Brown (UM)
Bobby W. Crissman (RTI)
Thomas B. Curtin (ONR)
Douglas J. Evans (EH)
Scott M. Glenn (HU)
Peter Hamilton (SAIC)
Robert C. Hamilton (EH)
Jerry Miller (UM)
Fred M. Vukovich (RIT)
Evans Waddell (SAIC)

Contracting Officer
Jeffrey Petrino
James D. Shilkett

COTR: Newell T. Stiles
David R. Browne

Key Words:
circulation/current study; hydrographic, temperature, salinity data; satellite-tracked drifters; meteorology

Objectives:

1. Perform a comprehensive study of the flow and temperature fields within frontal eddies and to the extent practicable, measurements of "slope currents."

2. Estimate the size and frequency of occurrence of these frontal events and evaluate their significance to shelf circulation in the study area.

Summary:

During the 6-month period from May to November, 1987, oceanographic measurements were made off North Carolina in order to examine the effects of Gulf Stream frontal eddies on the circulation of water over the continental shelf.

The measurements were grouped within two time intervals: 1) a 6-month time interval in which satellite images were collected daily, and currents were measured at eight moorings containing 21 current meters; and 2) a 2-week time period in May when eddies were intensively examined using satellite imagery, drifting buoys, aircraft and survey vessel launched temperature probes, and an Acoustic Doppler Current Profiler.

Results from both periods were combined with analysis of coastal winds, water temperature, and sea level data, as well as analyses of multi-year satellite images to provide a better understanding of the structure, movement, and frequency of frontal eddies.

The major conclusions of this study may be summarized as follows:

1. Off the North Carolina Coast, the Gulf Stream appears to behave in two distinct modes; the small and large meander modes.

2. During the small meander mode, the Gulf Stream Front lies at the shelf break and meanders of the front have smaller amplitudes. Frontal eddies and associated warm water filaments are smaller and farther from shore during this mode.

3. During the large meander mode, the Gulf Stream Front is displaced offshore of the shelf break and meanders of the Front have large amplitudes. Frontal eddies and associated warm water filaments are larger and closer to shore during this mode, with some of the filaments nearly reaching the Barrier Islands.

Eddies migrate past locations off the North Carolina coast approximately once every five days. After an eddy passes, parts of the filament may stagnate on the shelf for approximately a week before dissipating or moving northward out of the study area.

Final Report:

Frontal Eddy Dynamics (FRED) experiment off North Carolina. (Evans-Hamilton; 1989).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Available from NTIS:

Executive Summary	(Vol. I)	PB89-186936/AS
Technical Report	(Vol. II)	PB89-186944/AS

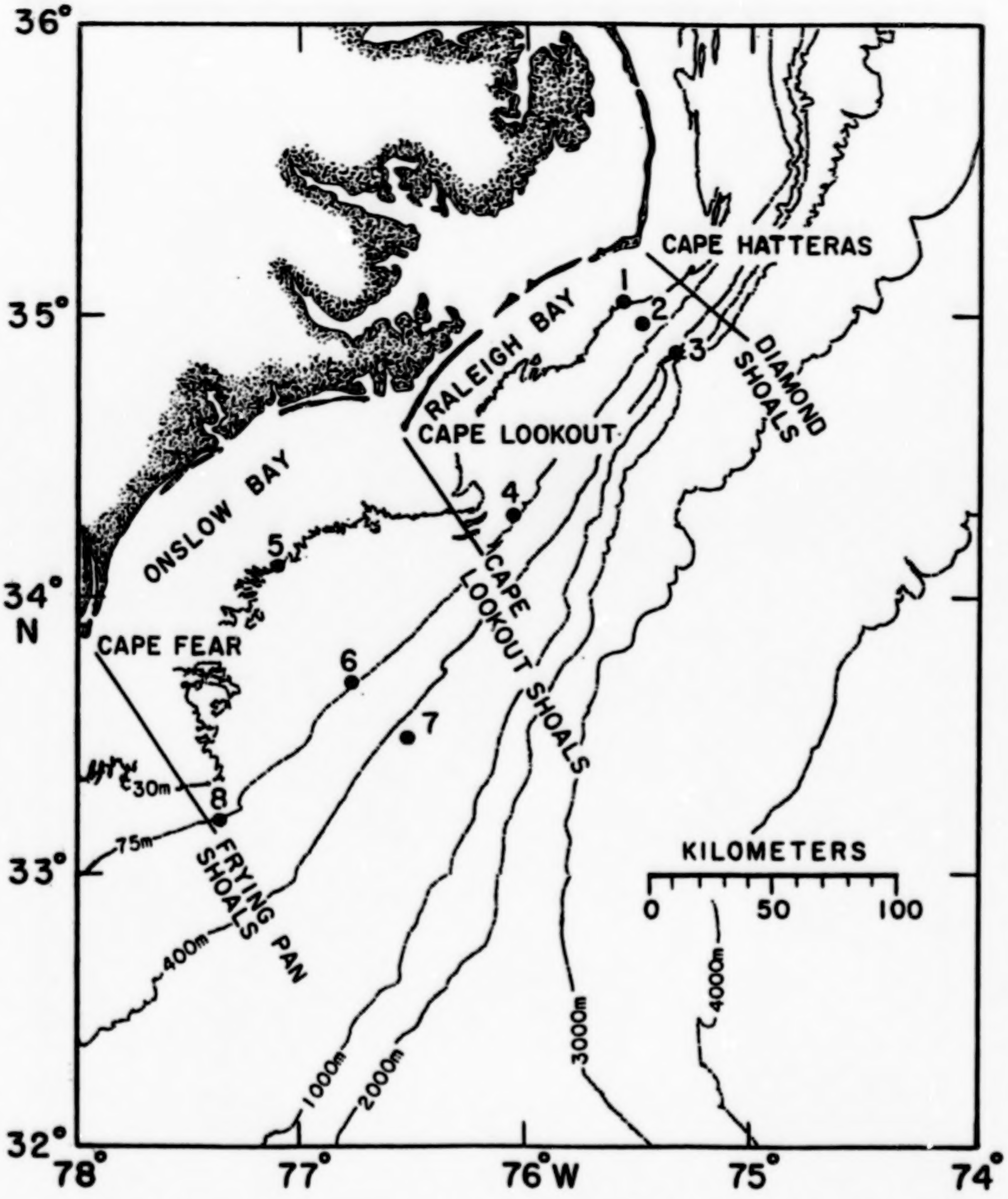

Figure 18. Study area topographic and bathymetric features. Mooring locations are also shown (dots numbered 1–8). The shelf break occurs approximately along the 75m isobath. (Source: MMS Contract No. 14–12–0001–30349).

Environmental Studies Index

Mid-Atlantic

Biology

BLM INTERAGENCY AGREEMENT NO.: AA550-IA7-35

Title: NMFS Middle Atlantic Biological Baseline Studies

Date: 17 June 1977 - January 1984

Cost: $550,000

Prime Contractor:
National Marine Fisheries Service (NMFS)
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, New Jersey 07732

Program Manager:
Robert N. Reid

Principal Participants:

Thomas Azarovitz	Robert A. Murchelano
Elizabeth S. Bevacqua	David J. Radosh
Charles J. Byrne	Aaron Rosenfeld
Linda I. Despres	W.G. Smith
Harold A. Foster	Roger B. Theroux
Ann B. Frame	Alice Wells
Donald G. McMillan	Thomas E. Wilhelm

Contracting Officer
Paul Lubetkin
Jeffrey P. Petrino

COTR: Eiji Imamura
Jeffrey L. Hyland

Key Words:
ecological characteristics; ecological study; benthic studies; ichthyoplankton; diseases; crustaceans; mollusks; fisheries-commercial

Objectives:
The purpose of this study was to support an environmental baseline study of the Mid-Atlantic Outer Continental Shelf (OCS) already initiated by Virginia Institute of Marine Science (VIMS) and U.S. Geological Survey (USGS). Objectives of this study are:

1. Provide summaries, biological analyses, and interpretations of the total data on trawl fisheries for the Mid-Atlantic OCS area.

2. Compile ichthyoplankton data and provide summaries, biological analyses, and interpretations of ichthyoplankton associations and distributions.

3. Provide biological analyses of 114 Baltimore Canyon Trough benthic grab samples, relate the resulting data to

sediment type, per cent organics, and existing heavy metal burdens, and report on the distribution and abundance of benthic fauna in the Mid-Atlantic Bight with respect to various chemical, geological, and physical parameters.

4. Conduct a bibliographic search, compilation, and documentation of diseases, abnormalities, and environmentally induced stresses of animals that inhabit U.S. waters.

Summary:
Report 1 - Distribution plots taken from spring and fall cruise data show that many of the more important finfish species found in the Mid-Atlantic Bight from Cape Cod to Cape Hatteras are not endemic but are seasonal migrants. Because of the absence of a discrete endemic fish fauna zoogeographers have been hesitant to recognize the Mid-Atlantic Bight as a separate faunal province. However, several species, whose distributions were summarized in this report, do have their centers of abundance in the Bight (e.g., summer flounder, windowpane, fourspot flounder, scup). Most individuals in these populations do not leave the Mid-Atlantic Bight, but migrate seasonally and concentrate in narrow bands along the margins of the area. For example, summer flounder concentrate in the inshore areas in summer, but migrate offshore and concentrate on the outer-shelf in the winter. Many of the other species (e.g., bluefish, Atlantic herring, Atlantic mackerel) undergo such extensive seasonal movements that they are virtually absent from the study area during the program's spring and autumn cruises.

Report 2 - This study summarizes ichthyoplankton data collected by the NMFS Sandy Hook Marine Laboratory from the Middle Atlantic Bight between 1965 and 1976. The plankton samples were collected on coastal surveys designed to monitor seasonal shifts in the distribution and abundance of planktonic fishes, and from site-specific studies designed to investigate the vertical distribution and diel movements of selected larvae. The report describes occurrences and seasonal patterns of numerically dominant larvae. All larval fish data from the three surveys are tabulated by station or by cruise. The results showed the seasonal nature of spawning in the Middle Atlantic Bight. In addition, the reports discussed intersurvey comparisons, distribution of fish eggs, community assemblages of larval fish, neuston collections, zooplankton volumes, and diurnal movements of larval fishes in relation to size, circulation, and temperature.

Report 3 - This study analyzed benthic grab samples from two sites in the Baltimore Canyon Trough. Surficial sediments were basically medium to fine sands; heavy metal (Cd, Cr, Cu, Ni, Pb, Zn) concentrations were low or undetectable, and the benthic infauna were dominated by polychaetes and peracarid crustaceans. An assessment of possible impacts from oil-related activities on benthos was also made.

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Report 4 - The significant infectious and non-infectious diseases of North American marine fishes and shellfishes were described in terms of host species, geographic range, gross lesions, etiology, method of diagnosis, and prognosis. Infectious diseases of fish and shellfish are caused by viruses, bacteria, fungi, protozoa, and metazoa. The non-infectious diseases discussed included those caused by aflatoxin, chlorine, gas bubbles, heavy metals, pesticides, and petroleum. Narrative sections explained the significance and importance of these diseases. The major genera of marine fishes and shellfishes and the major groups of infectious and non-infectious diseases included in the bibliography were tabulated. A glossary of terms used in the indices of infectious and non-infectious diseases of fish and shellfish was also included.

Final Reports:

Distribution and abundance trends of 22 selected species in the Middle Atlantic Bight from bottom trawl surveys during 1967-1979 (Objective 1). (T.R. Azarovitz, C.J. Byrne, E.S. Pritchard, L.I. Despres-Patanjo, H.A. Foster; 1985).

The distribution and abundance of ichthyoplankton in the Middle Atlantic Bight as determined from coastal surveys and site-specific studies, 1965-1976. NMFS Report No. SHL 79-02 (Objective 2). (W.G. Smith, A. Wells, D.G. McMillan; 1979).

Benthic survey of the Baltimore Canyon Trough, May 1974 final report. NMFS Report No. SHL 78-8 (Objective 3). (D.J. Radosh, A.B. Frame, T.E. Wilhelm, R.N. Reid; 1978).

Diseases of North American marine fishes, crustaceans and mollusks (Objective 4). (R.A. Murchelano, A. Rosenfeld; 1980).

Availability:

Available from NTIS:

Final Report (Objective 1) - NTIS number unavailable
Final Report (Objective 2) - PB81-214785
Final Report (Objective 3) - PB81-216020
Final Report (Objective 4) - PB81-216038

BLM CONTRACT NO.: AA551-CT8-32
MMS Contract No. 14-12-0001-29135

Title: Benthic Recolonization Study under Simulated Oil Spill Conditions in the Mid-Atlantic OCS Area

Date: 26 September 1978 - 9 January 1981

Cost: $560,172

Prime Contractor:
Virginia Institute of Marine Science (VIMS)
College of William and Mary
Gloucester Point, Virginia 23062

Subcontractors/Cooperating Institutions:
Advex Corporation
American University (AU)
Louisiana State University (LSU)
University of Virginia (UV)

Chartered Research Vessels:
R/V Cape Henlopen

Program Manager:
Eugene M. Burreson

Principal Participants:
D.F. Boesch
Michael Champ (AU)
Howard I. Kator
Craig L. Smith

Contracting Officer
A.F. Guida
Carroll D. Day

COTR: Philip Thomas
William H. Lang

Objectives:
The study consists of two phases: phase one, the development of a surface activated deployment and recovery system (SADRS) which contains recolonization boxes; phase two, deployment and recovery of the SADRS with actual recolonization experiments. The objectives of phase two were to:

1. Determine the sequence of benthic recolonization in the event of a pollution event.
2. Estimate the length of time necessary for a return to pre-pollution event populations (both numbers of species and species composition).

3. Determine the chemical changes in oil over time.

4. Develop predictive recolonization models for the major physiographic provinces of the Mid-Atlantic through the judicious siting of the recolonization experiments.

Summary:
In August 1979 six arrays of defaunated sediment were deployed at each of three sites on the Middle Atlantic Outer Continental Shelf (OCS). Three arrays at each site had Prudhoe Bay crude oil mixed with the sediment. The arrays were in place for 10 months. Corrosion of cables and other parts of the experimental apparatus limited recoveries to one rather than three as planned. Sediment was eroded from the containers by wave induced currents. Fouling organisms that were attracted to the structures included hydroids, caprellids amphipods, and young scallops. Larger animals used the experimental apparatus as a refugium (e.g., hakes, Urophycis spp., cancroid and galetheid crabs).

In general, colonization of azoic sediments by macrobenthos proceeded at a similar rate reported for natural OCS communities of the Middle Atlantic Bight. The colonization rate observed at the shelf break station was slightly lower than that of the shelf proper. Long-lived species that rely on planktonic larval dispersal were slower to establish populations than those with effective short-range dispersal (e.g., brooding amphipods, and polychaetes). Meiofaunal density and dry weight biomass were lower in all experimental boxes than in the natural community (246 per 10 m^2 vs. 34 per 10 m^2). Nematodes comprised between 82 and 94 per cent of the total meiofaunal abundance. Copepods, ostracods, polychaetes, and bivalves were also present. No significant differences existed between mid-oiled and control recoveries, but low and high oiled boxes had low meiobenthic densities. Colonization of oiled sediments by meiobenthos was not appreciably altered in oiled sediments, however, overall colonization was slower than previously reported. Lack of significant change in community composition between control and oiled treatments suggests a response to physically mediated conditions.

Petroleum degrading bacterial populations increased in sediments contaminated with crude oil. Biodegradation was limited to the oxygenated upper centimeters of sediment, and in general, weathering of crude oil was slow. As much as 91 per cent of the added oil remained; some toxic components of oil (methylnapthalenes and methyl phenanthrenes) persisted in moderate concentrations after the 295-day exposure period. Erosion may have been responsible for some losses. Low environmental temperatures, incorporation of oil into sediments, and oxygen and nutrient limited biodegradation were contributing factors of reduced weathering. The shelf break station retained more oil than the mid-shelf station.

Final Report:
Experimental colonization of crude oil contaminated sediments by benthos on the Middle Atlantic continental shelf. (D.F.

Boesch, E.M. Burreson, L.C. Schaffner, H.I. Kator, C.L. Smith, D.M. Alongi, M.A. Brown, P.O. deFur; 1981).

Availability:

Available from NTIS:

Final Report - PB81-223570.

MMS PURCHASE ORDER NO. 10244

Title: Effects of a Natural Disturbance on a Continental Shelf Live-Bottom Community

Date: 12 December 1984 - October 1985

Cost: $9,995

Prime Contractor:
Duke University (DU) Marine Laboratory
Beaufort, North Carolina 28516

Subcontractors/Cooperating Institutions:
University of North Carolina (UNC)
East Carolina University (ECU)
North Carolina Division of Marine Fisheries (NC)

Chartered Research Vessels:
R/V Cape Hatteras

Program Manager:
William W. Kirby-Smith

Principal Participants:
Dr. William W. Kirby-Smith (DU)
Dr. Larry Cahoon (UNC)
Mr. T. Boyton (UNC)
Mr. W. Sutherland (UNC)
Dr. Stan Riggs (ECU)
Dr. Joseph Ustach (DU)
Dr. T. Johnson
Steve W. Ross (NC)

Contracting Officer
Stephanie E. Innello

COTR: Timothy F. Sullivan

Objectives:
Determine the impact of a hurricane on a midshelf live-bottom community.

Summary:
Hurricane Diana was a major storm which would have been expected to cause significant damage to live-bottom communities on the mid continental shelf in the area near where the storm passed. The effects off Cape Fear shoals were expected to be particularly severe given that the storm was stalled in the vicinity for more than 24 hours. Biological sampling using 35 mm slides and TV transects revealed no quantitatively significant differences in live-bottom communities between pre and post hurricane samples which could be attributed to the hurricane. Damage observed which was probably hurricane-related was limited to observations of dead mussels, some

dead corals and necrotic spots on corals. Geological sampling revealed no effects of hurricane Diana in terms of erosion of ledges or sedimentary profiles. Coral heads appeared to have been damaged but not destroyed. These data suggest that mid-continental shelf live-bottom communities are not significantly damaged by wave energy and sediment scour associated with the passage of a major storm. This, it would appear temporary disturbance of the in situ sediment is not likely to have a severe or lasting impact on these communities and that communities are adapted to periodic sand scour and sediment movement.

Final Report:
Effects of a Natural Disturbance on a Continental Shelf Live-Bottom Community off North Carolina.

Availability:
A review copy is available at the Minerals Management Service, Herndon, Virginia.

Related Contracts:
CT9-27
CT1-18

Environmental Studies Index

South Atlantic

Workshops and Conferences

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BLM CONTRACT NO.: AA550-CT6-05

Title: South Atlantic OCS Studies Conference

Date: August 1975 - February 1976

Cost: $39,000

Prime Contractor:
Research Triangle Institute (RTI)
P.O. Box 12194
Research Triangle Park, North Carolina 27709

Program Manager:
Martin F. Massoglia

Principal Participants:
J.J.B. Worth
D. Menzel

COTR: Douglas Lipka

Key Words:
conferences/meetings/symposiums; fate and effects of oil; oil and gas resources; effects-ecological; program review

Objectives:

1. Provide a summary of available related information and understanding for the South Atlantic Outer Continental Shelf area.
2. Provide any predictions, presently possible, of the effects of drilling (exploration and development) on the environment in this area.
3. Identify subject areas in which additional information is required for reasonable prediction and understanding of the environmental effects of drilling in this area.
4. Formulate recommendations for baseline studies and monitoring which will help to determine the environmental effects of oil and gas exploration and development in the South Atlantic Outer Continental Shelf area.

Summary:
The Research Triangle Institute conducted a conference/workshop to determine the nature and extent of the environmental studies required to measure and monitor the effects of exploration and development on the marine environment. Participants consisted of knowledgeable and interested members of the scientific community, State and Federal Agencies, industry, and the public sector. Discussions and specific recommendations are included in the final report. The following were considered to be of major importance:

1. The possibility of accidents resulting from geologic hazards.
2. Permanent destruction of unique environments.
3. The effects of metals and hydrocarbons on organisms and the possible return of these elemental compounds to man.

It was determined that recommendations developed in the individual workshops should be prioritized as: 1) considering the direct impact on man and the environment of any oil and gas development activities; 2) weighing them according to the irreversibility of the impact; and 3) assembling them into interdisciplinary packages. Within this general framework, three priority groups were defined.

Group I. Baseline, Direct Impact on Man

1. Seismology and identification of faults and positions of aquifers, and test drillings to correlate with such a study.
2. Side-scan sonar mapping to identify hard bottom areas.
3. Inventory of metals and hydrocarbons in water, animals, and sediments.
4. Inventories of the seasonal abundance of birds, mammals, and reptiles.
5. Inventories of benthic organisms in direct support of 3 (same locations).
6. Trajectories and net transport of water.
7. Management of background and historical data.
8. Coordination of activities associated with fish populations currently being conducted by Federal, State, and private agencies.
9. Beach survey for tarballs.
10. Chemistry of suspended particulates.

Group II. Predictive Studies

1. Fate of oil in marshes, shelf, and open ocean:
    a. Distribution in fines and sediments,
    b. Bioaccumulation,
    c. Effects,
    d. Exchange phenomena at surfaces.
2. Fate of metals in marshes, shelf, and open ocean:

a. Distribution in fines and sediments,
b. Bioaccumulation,
c. Effects,
d. Exchange phenomena at surfaces.

Group III. All Others

Using these categories, recommendations were extracted from the overall list of individual workshop recommendations and prioritized into conference/workshop recommendations.

Final Report:

Conference/Workshop Proceedings: Bureau of Land Management's Environmental Studies Program for the South Atlantic OCS area (M.F. Massoglia, Comp.; 1976)

Availability:

Available from NTIS: PB80-195043

BLM CONTRACT NO.: **CT8-34**

Title: South Atlantic OCS Physical Oceanographic Modeling Evaluation

Date: 1978-1980

Cost: $186,586

Prime Contractor:
Jaycor
11011 Torreyana Rd.
San Diego, California 92121-1190

Program Manager:
R. Dowe

Principal Participants:
G. Janowitz
L. Pietrafesa
D. Tung
R. Weisberg

Contracting Officer:
Paul Lubetkin

COTR: Elwyn D. Wood

Key Words:
oil spill model; transport (physical processes); transport, oil; circulation/current study; conferences/meetings/symposiums

Objectives:

1. To determine which models, if any, were best suited to the BLM program needs in assessing the distribution of pollutants resulting from offshore activities and in assessing the probability of occurrence of circumstances hazardous to offshore structures.

2. To determine which models best fit the physics of the South Atlantic OCS region.

3. To assess the sensitivity of various models to data input.

4. To determine the quantity and quality of existing input data to drive the models.

Summary:
No generalized hierarchy of models for the South Atlantic OCS or any other OCS area was practically attainable at the time. Even if this was an attainable goal, there was no data base suitable to verify or use such a hierarchy. There were no predictive models available to deal with bedform movement and effects of bedform movement on

structures. To utilize a model for prediction of oil spill trajectory, one needs winds from the preceding days, current time and predictions immediately after spill. Water currents are important, particularly current direction within the mixed layer. One defines and matches boundary conditions differently to address different overruns or problems. A three dimensional time dependent model is not needed to address BLM questions. Norden's (Huang) surface layer model represented a progress point of significance to BLM. All models need both verification and sensitivity homework before being turned over for management use.

Final Report:

Proceedings of the continental shelf physical oceanographic model evaluation workshop. (R. Dowe, G. Janowitz, L. Pietrafesa, D. Tung, and R. Weisberg; 1980).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Available from NTIS: PB 81-124646

CONTRACT NO.: EQ4AC007

Title: A Socio-Economic Environmental Baseline Summary for the South Atlantic Region between Cape Hatteras, North Carolina, and Cape Canaveral, Florida

Date: September 1974

Prime Contractor:
Virginia Institute of Marine Science (VIMS)
Gloucester Point, Virginia 23062

Program Manager:
Maurice P. Lynch

COTR: Edward J. Tennyson

Key Words:
social/economic survey; ecological characteristics; chemical analysis; geology-general treatment; circulation/current study

Objectives:
To perform a base line survey for the South Atlantic region between Cape Hatteras, North Carolina, and Cape Canaveral, Florida of the: physical oceanography; climatology; chemistry; biology; geology; and social-economics

Summary:
The geographic area covered in this report extends from Cape Hatteras, North Carolina, in the north, to Cape Canaveral, Florida in the south. Included within this area are portions of the coastal areas of South Carolina and Georgia. All or portions of 30 coastal counties are included within the study area.

Estuaries in this area tend to be partially mixed due to relatively low runoff per mile of coast. The proximity of the Gulf Stream to the continental shelf and the low runoff combine to cause the salinity of the coastal water to be somewhat higher than that of the coastal water north of Cape Hatteras. Surface isotherms parallel the coast and temperatures generally increase seaward. Maximum horizontal gradients and minimum vertical gradients of temperature are usually found during winter.

This coastal region is warm temperate in character with a strong maritime influence. There is a tendency toward an annual division into two seasons, with higher precipitation during the summer than the winter. Local afternoon thundershowers produce most of the summer rainfall. Wind activity is generally low, flowing mainly from the northern quadrants in winter and southern quadrants during summer. Severe storm development is infrequent throughout the region.

Geologically, the area comprises the southern segment of the Atlantic Coastal Plain. The area between Cape Hatteras and Cape Romain is distinctive for its three large smooth scallops between Capes Hatteras, Lookout, Fear, and Romain. South of Cape Romain, the area is characterized by extensive salt marshes bordered by a belt of low lying islands, the "Sea Islands" of South Carolina and Georgia. South of the Sea Islands are extensive beaches and associated dunes which create lagoonal flats inland.

From a chemical standpoint, the area is characterized by generally low nutrient input from rivers, especially nitrogen, resulting in low phytoplankton production. Heavy detritus loads from adjacent salt marshes keep the oxygen level in estuaries below saturation. These streams have little capacity to assimilate additional oxygen demand.

Zoogeographically, the area comprises the Carolinian Province. At the northern end, long narrow barrier islands, well separated from the mainland, are backed by irregularly flooded marshes. The enclosed sounds with muddy bottoms and high turbidity, are productive nursery grounds for commercial fish and shellfish. Along South Carolina and Georgia, the salt marshes provide the base of the food chain for the estuaries. Along the remainder of the coast, the mainland is exposed to the sea. The offshore region is sandy throughout with outcroppings of coral, rock, and other substrates called live-bottom habitats which are productive of fishery products. The biota is basically temperate with a number of subtropical species.

Economically, the area of the study is generally depressed. The highest degree of urbanization has occurred at the major ports in the area: Wilmington, North Carolina; Charleston, South Carolina; Savannah, Georgia; and Jacksonville, Florida. Per capita income in the area is below the U.S. averages in 29 of the 30 counties. Six counties are primarily dependent upon manufacturing as a source of income, six on farming, nine on government (primarily military bases), three on services, and six have no dominant sector.

This area then, beginning just below the southern limit of the north eastern megalopolis and extending to the booming Florida peninsula, is one of the largest portions of relatively unspoiled, undeveloped sea coast in the contiguous United States. The possibility of rapid coastal development should be of prime concern to planners and managers at all levels of government and industry.

Final Report:

A socio-economic environmental baseline summary for the South Atlantic region between Cape Hatteras, North Carolina, and Cape Canaveral, Florida. (Vol. I - J.P. Jacobson; Vol. II - E.P. Ruzecki, R. May et al.; Vol. III - M.H. Roberts et al.; Vol. IV - J.M. Ziegler et al.; Vol. V - Virginia Institute of Marine Science; 1974).

Availability:

Available from NTIS:

- Final Report (Vol. I, Physical Oceanography) - PB80-216187
- Final Report (Vol. II, Climatology) - PB80-216286
- Final Report (Vol. III, Marine Chemistry and Biology) - PB80-216278
- Final Report (Vol. IV, Marine Geology) -PB81-110371
- Final Report (Vol. V, Socio-Economics) - PB81-127680

BLM CONTRACT NO.: AA550-CT7-39
MMS CONTRACT NO.: 14-12-0001-29004

Title: Summary and Analysis of Environmental Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canaveral

Date: 25 August 1977 - 1981

Cost: $261,901

Prime Contractor:
Center for Natural Areas (CNA)
P.O. Box 98
South Gardiner, Maine 04359

Subcontractors/Cooperating Institutions:
Chesapeake Biological Laboratory (CBL)
The Citadel (Cit)
John Hopkins University (JHU)
Old Dominion University (ODU)
Skidaway Institute of Oceanography (SIO)
University of Florida (UF)
University of Georgia (UG)
University of Rhode Island (URI)
University of South Carolina (USC)
Virginia Institute of Marine Science (VIMS)

Program Manager:
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Patricia E. Ryan (Coordinator)

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Contracting Officer:
Paul Lubetkin

COTR: Richard Defenbaugh

Key Words:
characterization-ecological; chemical analysis; ecological study; geology-general treatment; microbiology; plankton,

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zoo- and/or phyto-; fisheries-sport; fisheries-commercial; endangered species information; benthic studies; literature search (bibliography)

Objectives:
A complete survey (i.e., extending before 1974) was made of research conducted on the toxicity and microbiology in this geographical region. Special effort was taken to complement, but not duplicate except where noted, the literature survey conducted by the Virginia Institute of Marine Science (VIMS) (1974) on the continental shelf from Cape Hatteras to Cape Canaveral. Objectives are to:

1. Update the environmental survey by VIMS (1974) and provide analysis of all existing biological, chemical, and geological data.

2. Identify and summarize ongoing biological, chemical, and geological programs in the South Atlantic region.

3. Identify sources of raw data and unworked samples, and evaluate the role of this material in relation to the total existing data base.

4. Identify gaps in the biological, chemical, and geological data base and evaluate the extent of these gaps.

Summary:
The geographical area covered extends from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, from the spring tide mark to the 1,500 m isobath, encompassing four coastal states--North Carolina, South Carolina, Georgia, and Florida. Major topics inventoried and presented are Marine Geology, Chemistry, Phytoplankton, Zooplankton, Neuston, Nekton, Benthos, Commercial Fisheries, Sport Fisheries, Marine Benthic Flora, Marine Mammals, Marine Birds, Marine Turtles, Endangered or Threatened Species, Microbiology, Outer Continental Shelf (OCS) Uses, Unique or Endangered Environments, and Toxicity and Health Studies.

Compared with most shorelines of the Nation, the coast and continental shelf of the study area remain in a relatively undisturbed condition, with human population, industry, and shopping concentrated in relatively few coastal cities. The existing environment consists of bays, estuaries, marshes, and sounds, as well as long barrier beaches and the continental shelf, each of which may serve as essential breeding and/or feeding habitat for almost all species of coastal marine life. In North and South Carolina, all of the inshore and coastal environments have been classified as areas of critical State concern. The prospect of offshore petroleum and natural gas production has created the need for additional knowledge critical to the evaluation of hazards and to the development of management strategies designed to reduced the risks of irretrievable environmental damage.

The following data gaps were identified:

Geology
- Shallow and deep-core drilling for seismic correlation.
- Detailed mapping of sediments and topography of the sea floor.
- Occurrence, value, and accessibility of mineral deposits and environmental implications of mining them.

Chemistry
- Hydrocarbons and trace metals in inshore particulates, sediments, and biota.
- Hydrocarbons and trace metals in the offshore water column, sediments, and biota.

Phytoplankton
- Seasonal productivity patterns of the inner and outer shelf.
- Influence of various pollutants on locally occurring species.

Zooplankton
- Small and large-scale patterns of distribution and abundance in relation to the environmental factors which control them.

Neuston
- Survey of the areal and seasonal incidence of neustonic constituents.
- Relationships of neustonic species and hydrocarbons of various chemical types and physical states.

Marine Benthic Flora
- Distribution of algal species on offshore hard bottoms.
- Factors which control the distribution of marine benthic algal species in the area.

Microbiology
- Dynamics of the microbial organisms of estuaries in relation to total ecosystem metabolism, and especially the higher trophic levels.
- Total spectrum petroleum-decomposing abilities of microorganisms characteristic of each coastal, shelf, and slope habitat.

Benthos
- Distribution and dynamics of macrobenthos of the shelf, with special reference to the hard bottoms.
- Functional roles of the benthos in the overall metabolism of estuarine and shelf systems needs further study and quantification.

Nekton
- Species studies within the context of the broader ecosytems of which they are integral parts.

Turtles

- Breeding activities (by site and season) and methods of reducing nest and hatchling mortality.
- Natural history and population phenomena of hatchlings during the critical first year of life.
- Migration and population phenomena of older turtles which utilize the area.

Birds

- Seasonal distribution patterns for pelagic seabirds.
- Feeding ecology for pelagic and nearshore species.
- Effects of oil platforms on migration and food supplies.

Mammals

- Information on local movements and migrations.
- More complete information on population sized of resident and migrant populations and species.

Commercial Fisheries

- Physical and biological factors affecting recruitment and survival.
- Relations of the sports fishery to the commercial fishery for each species, and relations of the species within the ecosystems.

Threatened and Endangered Species

- Further studies are needed to establish the status of many species currently listed as "status uncertain".
- The factors which lead to the decline of each species should be investigated on a case-by-case basis to provide insights for more effective species protection strategies.

Unique or Endangered Environments

- Virtually nothing is known of the distribution of critical habitats on submerged lands of the shelf, and the only protected sites are a Civil War Ship and a number of artificial fishing reefs. Survey and site designation here is a critical gap.

Toxicity and Health Studies

- Information concerning biological effects of sublethal and chronic exposure to individual toxicants.
- Information concerning combined effects of multiple exposures to these substances.

Final Report:

A summary and analysis of environmental information on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. (CNA; 1979).

Availability:

Available from NTIS:
Final Report (Vol. I, Bk. 1, Introduction, Geology, Chemistry, Phytoplankton, Zooplankton, Neuston, Neston) - PB80-184096

Final Report (Vol. I, Bk. 2, Benthos, Commercial Fisheries, Sport Fisheries, Marine Benthic Flora, Marine Mammals, Marine Birds) - PB80-184104

Final Report (Vol. I, Bk. 3, Marine Turtles, Endangered Species, Microbiology, OCS Uses) - PB80-184112

Final Report (Vol. I, Bk. 4, Endangered Environments, Toxicity and Health Studies, Summary and Synthesis) - PB80-184120

Final Report (Vol. II, Master Bibliography, Index, Acknowledgements) - PB80-201700

Appendices (Vol. III) - PB80-208945

BLM CONTRACT NO.: AA851-CT1-68
MMS CONTRACT NO.: 14-12-0001-29189

Title: North Carolina Fisheries and Environmental Data Search and Synthesis Study

Date: 30 September 1981 - September 1983

Cost: $169,730

Prime Contractor:
Continental Shelf Associates, Inc. (CSA)
759 Parkway Street
Jupiter, Florida 33477-4567

Subcontractors/Cooperating Institutions:
Florida Atlantic University (FAU)
Harbor Branch Foundation (HBF)

Program Manager:
David A. Gettleson

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COTR: William H. Lang

Key Words:
fisheries-commercial; fisheries-sport; endangered species information; benthic studies; literature search (bibliography)

Objectives:

1. Collect and annotate information on living resources and habitats of the North Carolina Outer Continental Shelf (OCS) to 200 meters.

2. Produce a computer program to file and sort annotated references based on key words, authors, and geographic location. Include with this program the complete North Carolina (NC) data base, operators manual, and key word thesaurus.

3. Write a final report to update and expand on previous BLM (now MMS) literature reviews (EQ4AC007, CT7-16, CT7-39) for the specified NC study area.

Summary:
Available information on the living marine resources and habitats of the North Carolina OCS, from shore to a depth of 200 m (656 ft) was collected, annotated, and synthesized. Over 1,450 published and unpublished data sources were reviewed. Written synthesis chapters summarized the geology, oceanography, biological communities, commercial and sport fisheries, endangered and threatened species, and sensitive biological areas and unique habitats. Data gaps were identified, implications to OCS development were discussed, and suggestions for additional research were provided. In addition, a computer program was designed to catalog and sort all of the pertinent annotated information sources. The purpose of this computer program was to provide the Minerals Management Service (MMS) with a useful and viable method of maintaining, updating, and expanding the data base.

The North Carolina OCS is a transition zone between the South and Middle Atlantic Bight. The climate, proximity, and behavior of the Gulf Stream, and the presence of cuspate projecting shoals and capes influence unique oceanographic and biological features. Extensive hard/live bottom areas are present within Onslow Bay and along the North Carolina continental shelf edge. Upwelling along the North Carolina continental shelf edge and the intrusion of nutrient rich eddies into middle- and inner-shelf waters occur frequently along this coast. The upwelling-eddy, formation- intrusion phenomenon is not well understood and its ecological implications are just beginning to be studied. The present lack of knowledge in this area makes risk assessment for OCS development activities difficult. Additional studies of the coupling of physical and biological processes along the North Carolina continental shelf are needed in order to formulate effective OCS management policies for that area.

Overall phytoplankton abundance and species diversity tend to decrease with distance from shore. Phytoplankton communities have a regional demarcation in the Cape Hatteras vicinity with neritic and pelagic species south of the Cape exhibiting subtropical and tropical affinities, and species north of the Cape exhibiting temperate or boreal affinities. Generally, total zooplankton concentrations tend to decrease with distance offshore. A total of 67 fish families have been identified from surface ichthyoplankton samples off North Carolina and another 60 fish families from midwater samples. Three distribution patterns occur, characterized by families spawning in the area, including the shelf, shelf/slope, and slope patterns. Benthic organisms also have three distribution patterns: along the inner shelf; the Carolinian Province south and the Virginian Province north of Cape Hatteras; and the Tropical or Caribbean Province on the outer and upper slope associated with the Gulf Stream. Seasonal fluctuations in province boundaries occur. Algal flora from coastal North Carolina are represented by 289 taxa. This diversity is due to the variety of available habitats and seasonally variable environment allowing growth of both temperate and subtropical species. Meiobenthic faunal distribution patterns are highly correlated with sediment composition and bottom water temperature. Density values are highest in the inner-shelf and mid-shelf depth ranges and lowest in depths beyond 100 m (328 ft). Live-bottom sessile invertebrate communities are of two types: (1) exposed eroded carbonate rock outcrops within and near Onslow Bay encrusted with coral and other associated epifauna; and (2) lithothamnion reef assemblages occurring along the shelf edge.

Fishes comprise the most abundant portion of the nektonic community off North Carolina with temperate to subtropical species found nearshore and subtropical to tropical species offshore. During 1981, a total of 388,552,891 lb of finfish were landed in North Carolina, valued at $36,280,328. This catch was represented by 55 finfish species with Atlantic croaker, Atlantic menhaden, flounders, and grey seatrout leading in terms of value. In 1981, the total shellfish harvest was 43.452,992 lb, valued at $21,239,682. Shrimps, oysters, calico scallop, and bay scallop comprised 99 per cent of the catch. Five species of marine turtles, 8 species of fishes, and 27 species of marine mammals that are protected by the Endangered Species Act of 1973 exist in or migrate through North Carolina OCS waters.

Four types of sensitive biological areas and unique habitats are recognized on the Carolina Shelf: (1) inner-shelf, live-bottom areas; (2) mid-shelf, live-bottom areas; (3) shelf-edge, live-bottom areas; and (4) numerous shipwrecks. Six major areas have been identified where additional studies are needed: (1) mapping and description of hard-bottom and live-bottom areas; (2) coupling of shelf upwelling events with bioproductivity; (3) review of existing data for relationships of upwelling data and fishery data; (4) fates and effects of continental and OCS substances discharged into the marine environment; (5) re-evaluation of OCS risk analyses models; and (6) multidisciplinary monitoring programs to investigate potential effects of OCS activities on endangered species and unique habitats in the study area.

Final Report:

North Carolina fisheries and environmental data search and synthesis study. (CSA; 1983).

Availability:

Available from NTIS:
Executive Summary - PB84-141357
Final Report - PB84-141365

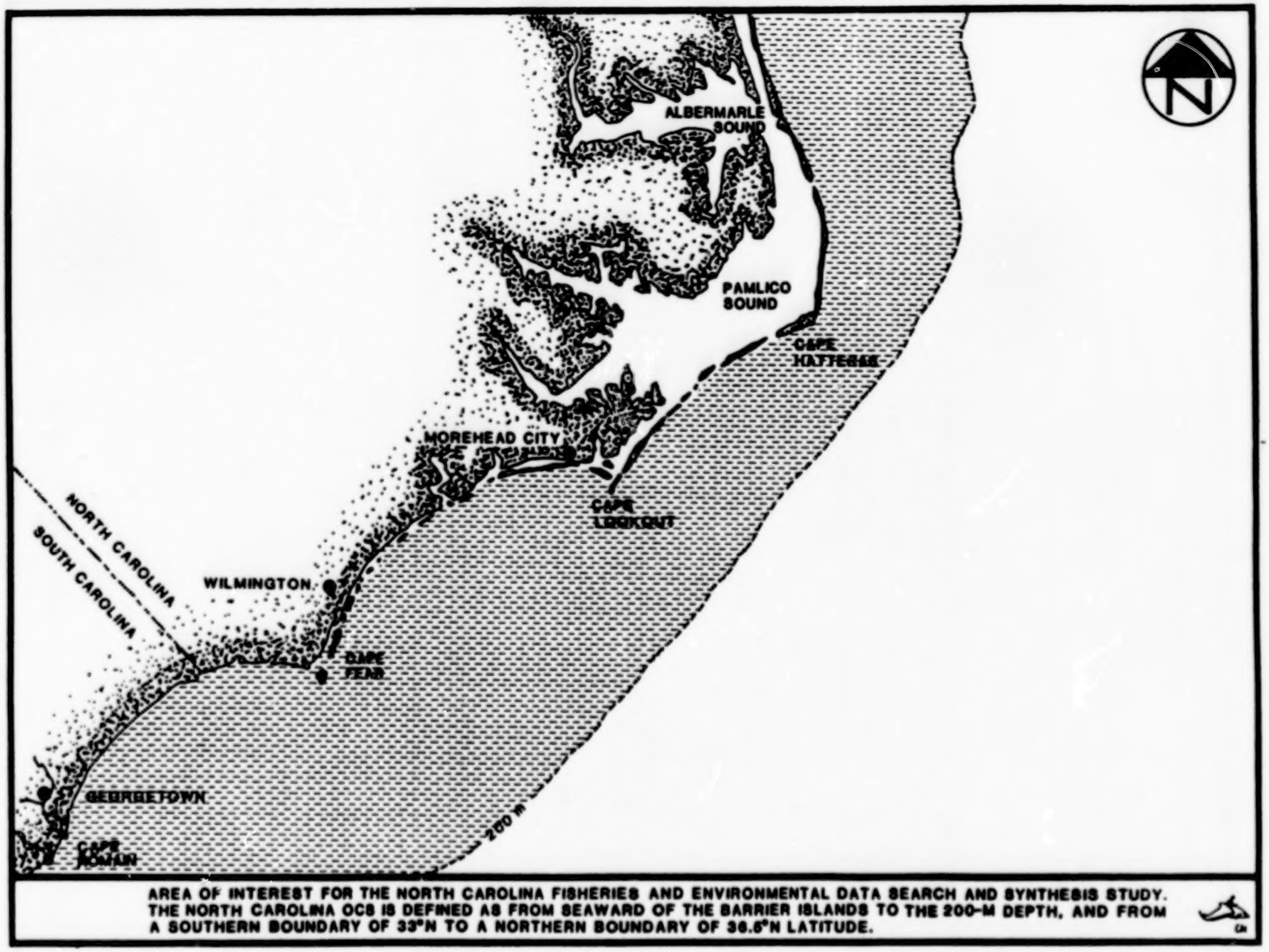
ALBERMARLE SOUND
PAMLICO SOUND
CAPE HATTERAS
MOREHEAD CITY
CAPE LOOKOUT
NORTH CAROLINA
SOUTH CAROLINA
WILMINGTON
CAPE FEAR
GEORGETOWN
CAPE ROMAIN
200 m
N
AREA OF INTEREST FOR THE NORTH CAROLINA FISHERIES AND ENVIRONMENTAL DATA SEARCH AND SYNTHESIS STUDY. THE NORTH CAROLINA OCS IS DEFINED AS FROM SEAWARD OF THE BARRIER ISLANDS TO THE 200-M DEPTH, AND FROM A SOUTHERN BOUNDARY OF 33°N TO A NORTHERN BOUNDARY OF 36.5°N LATITUDE.

Figure 19. Study area for the "North Carolina Fisheries and Environmental Data Search and Synthesis Study." (Source: MMS Contract No. 14-12-0001-29189).

MMS CONTRACT NO.: 30417

Title: Synthesis of Available Biological, Geological, Chemical, Socioeconomic, and Cultural Resource Information for the South Florida Area

Date: September 27, 1988 - May 1990

Cost: $359,260

Prime Contractor:

Continental Shelf Associates, Inc.
759 Parkway Street
Jupiter, Florida 33477-4567

Subcontractors/Cooperating Institutions:

- University of South Florida (USF)
- Florida Institute of Technology (FIT)
- CCC Enterprises, Inc. (CCC)
- Technology Management Group (TMG)
- Bowdoin College (BC)
- Florida Department of Natural Resources (FDNR)
- University of Miami (UM)
- Texas A & M University (TAMU)
- Florida State University (FSU)
- University of Virginia (UVA)
- Harbor Branch Oceanographic Institute (HBOI)

Program Manager:

Richard M. Hammer

Principal Participants:

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- W. Alevizon (FIT)
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- O. Owre (UM)
- C. Clausen (CCC)
- P. Sorensen (FSU)
- A. Hart (CSA)
- D. Getter (TMG)
- E.S. Gilfillan (BC)

Contracting Officer:
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COTR: Judith M. Wilson

Key Words:
characterization-ecological; cultural resources; fisheries study; literature search (bibliography); marine sea turtles; social/economic survey; geology-general treatment; plankton, zoo- and/or phyto; marine mammal; sea birds; benthic studies; coral reefs, biology

Objectives:
The objective of this study is to collect and synthesize all the available biological, geological, chemical, socioeconomic and cultural resource information for the South Florida area (south of 26° N. latitude). Data gaps in the information base are to be identified for the specific topics mentioned above and recommendations for need research are to be made.

South Atlantic

Socio-economics

BLM CONTRACT NO.: **AA551-CT8-40**

Title: Summary and Analysis of Cultural Resources Information on the Continental Shelf from Cape Hatteras, North Carolina, to Key West, Florida

Date: 18 September 1978 - December 1981

Cost:
$186,453
$ 6,682
$ 28,582
$221,717

Prime Contractor:
Science Applications, Inc. (SAI)
1764 Old Meadow Lane, Suite 400
McLean, Virginia 22102

Subcontractors/Cooperating Institutions:
Thunderbird Research Corporation (TRC)
New Found Harbor Marine Institution (NFHMI)
University of South Florida (USF)

Program Manager:
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Daniel Koshi-Karrel (USF)
John D. Milliman (WHOI)
Loreli Rappelye (TRC)
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S.David Webb (USF)

Contracting Officer:
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Carroll D. Day

COTR:
Richard Defenbaugh
Murray Brown
Mark Grussendorf

Key Words:
cultural resources; geology-general treatment; historic review; sediments (geology)

Objectives:

1. Review the later Quartenary geology of the study area, Mean High Water (MHW) to the 200-m isobath, as it relates to the cultural resources.

2. Assess the cultural resources that can be found (with specific emphasis on prehistoric archaeology and historic shipping).

3. Determine the probability of resource occurrence by area and/or feature (including map depicting cultural resource zones).

4. Identify potential pilot study areas.

5. Review present study techniques and provide recommendations for modification of search and recovery techniques.

6. Delineate significant data deficiencies.

7. (MOD. 2). Arrange a seminar on the prehistoric model.

Summary:
Sedimentary characteristics (composition, load, and mobility) and water movements were considered important in preserving, destroying, or moving various artifacts.

Paleo-rivers on the submerged shelf were likely locations for prehistoric human habitation during exposed periods (Pleistocene and Holocene). Rivers provided important lithic materials and sources of freshwater and attracted game animals. Several present-day coastal plain and piedmont rivers exist on the submerged shelf off North Carolina (i.e., White Oak and Cape Fear). The Santee River has been traced onto the shelf off South Carolina. The Georgia OCS was traversed by the Savannah and Altamaha rivers. In northern Florida, the St. Johns and St. Marys rivers extended on the shelf. Whether prehistoric man ever inhabited areas on the emergent shelf is not directly discernable, but predictions can be made using information concerning availability and location of required resources.

Cape Hatteras and southern Florida contain the highest densities of shipwrecks. The highest shipwreck concentrations occur along the shoals of Cape Hatteras, Cape Lookout, and Cape Fear. Over 500 shipwreck sites were documented for southern Florida. Most shipwrecks along the Georgia and South Carolina coasts occur inshore of the 20 m isobath. Expected impacts from OCS oil and gas activities will vary according to type of operation and where it is focused. Three areas of concern include: (1) offshore waters where drilling and monobouy terminal construction would occur; (2) inshore waters which will be traversed by pipelines; and (3) coastal waters where storage, pumping and support facilities would be built.

The synthesized data were used to develop management schemes which would protect, identify, and enhance cultural resources. The prehistoric archaeological model was based on distribution of environmental variables and how they might act to preserve, destroy, or concentrate artifacts. Management Zone I consisted of the 12,000 year shoreline along the South Carolina and Georgia coasts.

Management Zone II encompassed the area within the 16,000 year shoreline. Shipwreck sensitivity zones were designated inshore of the 20 m isobath off North Carolina and Florida.

Final Report:

A cultural resource survey of the continental shelf from Cape Hatteras to Key West. (SAI; 1981).

Availability:

Available from NTIS:

- Final Report (Vol. I, Introduction and Physical Environment) - PB82-138215
- Final Report (Vol. II, Prehistoric Archaeology) - PB82-138223
- Appendices (Vol. III) - PB82-138231
- Final Report (Vol. IV, Conclusions and Recommendations) - PB82-138249

South Atlantic

Geology and Chemistry

BLM INTERAGENCY AGREEMENT NO.: AA550-MU6-56

Title: South Atlantic OCS Geological Studies, FY '76

Date: 30 September 1976 - August 1979

Cost: $1,152,032

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Key Words:
geology-general treatments; sediments (geology); transport (physical processes); hazards-geologic sediment characteristics

Objectives:
The objectives of the U.S. Geological Survey's geologic environmental research program were to:

1. Measure the rate of sediment mobility over the seabed and monitor resultant changes in bottom morphology and texture.
2. Determine the concentration, distribution, and flux of suspended particulate matter in the water column.
3. Determine the vertical distribution of trace metals in the near surface sediment at selected locations.
4. Evaluate potential geologic hazards to oil and gas development due to surficial and intermediate depth structure and mass sediment transport events.
5. Identify and determine the significance of outcrop and reef structures.
6. Support the activities of the chemical/biological benchmark contractor by obtaining supportive sediment texture, composition, and physical oceanographic information.

Summary:
These studies cover investigations of the water column down to the deeper stratigraphy. Each chapter deals with a different topic.

The suspended load varies seasonally; highest in the winter, slightly lower during the summer, and considerably lower during the spring and fall. Inshore suspended loads were higher than offshore loads, probably reflecting input of sediment from the Savannah and Altamaha rivers and seasonal storms.

The study indicates that the shelf is not a sink for pollutants, as fine-grained particles are sparse on the shelf and that river generated fines ultimately bypass the shelf to be deposited on the slope and rise.

Transmissiometer profiles indicate that a surface or near-surface turbidity maximum is a persistent feature during the March, June, and August sampling periods. This feature is typically 5-15 m thick and is related to higher concentrations of planktonic organisms.

The bottom currents on the middle part of the South Atlantic shelf were typically 20 cm sec^{-1} and were dominated by the semidiurnal tide. Superimposed on the tidal currents were low frequency fluctuations of 5-10 cm sec^{-1} probably caused by Gulf Stream intrusions or wind stress and high frequency motions of 5-15 cm sec^{-1} probably associated with internal waves.

The study results suggest the following general conclusions: although patchiness occurs, nearshore sediments tend to be fine-grained sand whereas central and outer shelf tend to be coarse grained. Slope sediments are also fine-grained. Surficial sediments, bottom currents, and suspended sediments within the water column were related to surface and internal waves, tides, storm-driven currents, and the Gulf Stream. Trace metals levels were indicative of uncontaminated conditions throughout the surficial sedimentary layer. Hard-bottom areas n the South Atlantic OCS were infrequent and found mostly offshore of Florida, South Carolina, and North Carolina. With proper precautions, only strong currents of the Gulf Stream will present a major hazard to exploration or development on the continental margin. Proper rig placement and engineering will overcome any geohazards present in the study area.

Final Report:

Final report--environmental studies, southeastern United States Atlantic Outer Continental Shelf, 1977--geology. U.S. Geological Survey Open File Report 80-146, 651 p., 3 sheets, 6 microfiche. (USGS; 1979).

Final executive summary report--environmental studies, southeastern United States Atlantic Outer Continental Shelf, 1977--geology. U.S. Geological Survey Open File Report 80-147, 52 p. (USGS; 1979).

Availability:

Final Report is available from Minerals Management Service Herndon, Virginia

Other Publications/Reports:

Blackwelder, B.W., O.H. Pilkey, and J.D. Howard. 1979. Late Wisconsinian sea level on Southeast U.S. Atlantic shelf based on in-place shoreline indicators. Science 204:618-620.

Bothner, M.H., P.J. Aruscavage, W.M. Ferrebee, and P.A. Baedecker. 1980. Trace metal concentrations in sediment cores from the continental shelf off the southeastern United States. Estuarine and Coastal Shelf Science 10:523-541.

Edsall, D.W. 1979. Southeast Georgia Embayment high-resolution seismic reflection survey. U.S. Geological Survey Open File Report 78-800, 90 p.

Edsall, D.W., and W.P. Dillon. 1977. Geological development of Cenozoic continental margin of Southeast Georgia Embayment (abs.). American Association of Petroleum Geologists, Abstracts, p. 92.

Paull, C.K. and W.P. Dillon. 1979. The formation of the Florida-Hatteras slope (abs.). Geological Society of America, Abstracts with Programs 11(4):207.

_______________. 1980. Structure, stratigraphy, and geologic history of the Florida-Hatteras shelf and inner Blake Plateau. American Association of Petroleum Geologists Bulletin 64:339-358.

Popenoe, P. 1978. Geologic hazards of offshore oil exploration: Offshore Oil Structures Seminar Program, Colegio de Ingenieros Arquitectos y Agrimensores, San Juan, Puerto Rico, January 19-20, 1978.

Sylwester, R.E. and W.P. Dillon. 1977. Active growth fault seaward edge of Blake Plateau. Geological Society of America, Abstracts with Programs 9(7):1195.

U.S. Geological Survey. 1979. South Atlantic Outer Continental Shelf geological studies, fiscal year 1976, geology. P. Popenoe (ed.). U.S. Department of Commerce National Technical Information Service Report PB 300820, 562 p.

Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31
MU6-29
MU8-21
MU8-24
MU9-04
MU9-08/29166

BLM INTERAGENCY AGREEMENT NO.: AA551-MU8-13

Title: Geological Oceanography of the South Atlantic OCS Region (Year 2)

Date: 8 February 1978 - 17 July 1981

Cost: $984,598

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Duke University (DU)
University of Georgia (UG)
University of South Florida (USF)
Woods Hole Oceanographic Institution (WHOI)

Program Manager:
Peter Popenoe

Principal Participants:
Mark Ayers (DU)
Mahlon M. Ball (USGS)
Peter R. Betzer (USF)
Mike Bothner (USGS)
Bradford Butman (USGS)
Zack Clayton (USF)
Elizabeth L. Coward (USGS)
Larry J. Doyle (USF)
Francis D. Foley (UG)
R.T. Giles (UG)
Vernon J. Henry (UG)
David S. Hosom (WHOI)
Peter Johnson (USGS)
David R. Kendall (UG)
Charles J. McCreey (UG)
T.H. McKissack (UG)
Marlene Noble (USGS)
Marshall L. Otter (USGS)
Marshall H. Orr (WHOI)
M.A. Peacock (USF)
Orrin Pilkey (DU)
Paul R. Pinet (USGS)
Paul Schroeder (USF)
W. Strahle (USGS)
Frederick M. Wall (USF)

Contracting Officer:
Paul Lubetkin

COTR: Elwyn D. Wood
Murray Brown

Key Words:
geology-general treatment; sediments (geology); transport-sediments; transport (physical processes)

Objectives:

1. Determine the sedimentation rate and processes on the upper slope and inner Blake Plateau (piston cores).
2. Determine the distribution, areal extent, and vertical characteristics of geological features supportive of biological communities.

3. Monitor the transport of bottom sediments across the Outer Continental Shelf (OCS); evaluate its possible effect on pollutant transfer along the seabed and the potential of sediment as a pollutant sink; determine the implications of erosion/deposition on pipeline emplacement; and aid the interpretation of chemical, biological, and physical data (includes construction of third tripod and deployment - recovery and data reduction covered on FY '79 Memorandum of Understanding).
4. Complete analysis of benchmark seston samples (effort modified).
5. Study the shelf edge and slope near areas of oil and gas interests and the northern portion of the Blake Plateau for evidence of geological instability.

Summary:

This report is a summary of the second year of marine environmental research activities by the U.S. Geological Survey (USGS) on the southeastern U.S. Atlantic Continental margin, in accordance with Memorandum of Understanding (MOU) AA551-MU8-13 between the USGS and the Minerals Management Service (MMS) (formerly Bureau of Land Management).

The report covers studies whose fieldwork was conducted during the period from 1 October 1977 to 30 September 1978.

Chapter 2 discusses chemical variations in particulate matter within the water column, Chapters 3 to 5 discuss results of sampling of bottom sediments, Chapter 6 discusses the reefs and hard ground of the Georgia Bight, and Chapters 7 and 8 the stratigraphy and geologic hazards as defined by seismic-reflection surveys.

Eight large maps showing the distribution of reefs, hard grounds, benthic organisms, and bed forms, six plates showing line drawings of seismic stratigraphy, and one large map defining the distribution of geologic hazards to petroleum exploration and development are included in a pocket in the rear of this volume. Also included on microfiche film are appendices for Chapters 2, 3, 4, and 5.

Total suspended load (amorphous silicates, aluminum silicates, and trace metals) increased in a seaward direction while carbonate and organic content exhibited a reverse trend. The Florida Current was responsible for sediment transport and resuspension, especially on the outer shelf. On the slope at Cape Hatteras, sand and calcium carbonate fractions increased relative to the north, revealing a sedimentological break. The continental slope was an area of deposition relative to the adjacent shelf. Significant bed load spillover across the shelf suggested that the slope was a potential sink for pollutants. Geological hazards, though considered minor, included carbonate features, Florida Current effects, and frozen gas

hydrate layers on the Florida-Hatteras Slope between the 400 and 500 m isobaths.

Final Report:

A summary of environmental geologic studies on the southeastern United States Atlantic Outer Continental Shelf 1977-1978. U.S. Geological; Survey Open-File Report 81-583, 45 p. (P. Popenoe; 1981)

Environmental geologic studies on the southeastern Atlantic Outer Continental Shelf, 1977-1978. United States Geological Survey Open-File Report 81-582-A, 81-582B, appendices, 691 p. 15 plates (P. Popenoe, ed.; 1981).

Availability:

Available from NTIS:
Executive Summary - PB82-109273
Final Report - PB82-109265

Other Publications/Reports:

Ayers, M.W., L.J. Doyle, and O.H. Pilkey. 1982. Depositional processes of the Florida-Hatteras slope and inner Blake Plateau (abs). American Association of Petroleum Geologists, Atlantic Margin Energy Conference, Oct. 4-6, 1981.

Behrendt, J.C., R.M. Hamilton, H.D. Ackermann, V.J. Henry, and K.C. Bayer. 1980. Seismic reflection evidence for Cenozoic reactivation of older faults on land and offshore in the area of the Charleston, South Carolina, 1886 earthquake. Geological Society of America, Abstracts with Programs 12(7):384-385.

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Doyle, L.J., O.H. Pilkey, and C.C. Woo. 1979. Sedimentation on the eastern U.S. continental slope. In: Geology of Continental Slopes. O.H. Pilkey and L.J. Doyle (eds.). Society of Economic Paleontologists and Mineralogists Special Publication 27, pp. 119-129.

Foley, F.D., 1981. Neogene seismic stratigraphy and depositional history of the lower Georgia coast and continental shelf. Master's thesis under the supervision of V.J. Henry. Athens, GA: University of Georgia.

Foley, F.D., and V.J. Henry. 1981. Neogene seismic stratigraphy and depositional history of the lower Georgia coast and continental shelf. AAPG/SEPM Atlantic Margin Energy Conference, Atlantic City, October 4-6, 1981.

Folger, D.W., B. Butman, H.J. Knebel, and R.E. Sylwester. 1978. Environmental hazards on the Atlantic Outer Continental Shelf of the United States. Tenth Offshore Technology Conference, Houston, Texas, 2: 2293-2306.

Knebel, H.J. 1980a. Processes controlling the characteristics of the sand sheet, U.S. Atlantic Outer Continental Shelf (abs.). American Association of Petroleum Geologists Bulletin 64:733.

_______________. 1980b. Processes controlling the characteristics of the surficial sand sheet, U.S. Atlantic Outer Continental Shelf, *In: Sedimentary dynamics of continental shelves.* Nittrouer, C.A. (ed.). Developments in Sedimentology 32: Amsterdam: Elsevier, pp. 349-368.

Manheim, F.T., P. Popenoe, W. Siapno, and C. Lane. 1982. Manganese-phosphorite deposits of the Blake Plateau. *In: Marine mineral deposits.* P. Halbach and P. Winter. (eds.). Proceedings of the Clausthaler Workshop, Essen, West Germany, September 1982, Verlay Gluckauf Gmb H., pp. 9-44.

Paull, C.K., P. Popenoe, W.P. Dillon, and S.M. McCarthy. 1980. Geologic subcrop map of the Florida-Hatteras shelf, slope, and inner Blake Plateau. U.S. Geological Survey Miscellaneous Field Investigations Map MF-1171, scale 1:500,000.

Pilkey, O.H., B.W. Blackwelder, J.D. Howard, and H.J. Knebel. 1979. History of the Georgia Embayment sediment cover (abs.). Geological Society of America, Abstracts with Programs 11(4):209.

Pilkey, O.H., B.W. Blackwelder, H.J. Knebel, and M.W. Ayers. 1981. The Georgia Embayment shelf: Stratigraphy of a submergence. Geological Society of America Bulletin 92:52-63.

Pinet, P.R., and P. Popenoe. 1980. Cenozoic flow patterns of the Gulf Stream over the Blake Plateau (abs.). Geological Society of America, Abstracts with Programs 12(7):500.

_______________. 1981a. Effects of large scale shifts of the Gulf Stream on Miocene sedimentation patterns. American Association of Petroleum Geologists Atlantic Margin Energy Conference, October 4-6, 1981.

_______________. 1981b. Shallow seismic stratigraphy and post-Albian geologic history of the northern and central Blake Plateau (abs.). Geological Society of America, Abstracts with Programs 13(7):529.

___________. 1982a. Blake Plateau; control of Miocene sedimentation patterns by large-scale shifts of the Gulf Stream axis. Geology 10:257-259.

___________. 1982b. Late Cretaceous depositional patterns on the Blake Plateau (abs.). Geological Society of America, Abstracts with Programs 14(1-2):73.

___________. 1985a. A scenario of Mesozoic-Cenozoic ocean circulation over the Blake Plateau and its environs. Geological Society of America Bulletin 96(5):618-626.

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Pinet, P.R., P. Popenoe, and D.F. Nelligan. 1981. Gulf Stream: Reconstructions of Cenozoic flow patterns over the Blake Plateau. Geology 9(6):266-270.

Popenoe, P. 1979. Geological hazards and constraints to petroleum exploration and development on the southeastern United States continental shelf, slope, and Blake Plateau (abs.). Second Symposium on the Geology of the Southeastern Coastal Plain, March 5-6, 1979, Program and Abstracts, pp. 19-20.

___________. 1980. Single-channel seismic-reflection profiles collected on the northern Blake Plateau, 29 September to 19 October 1978. U.S. Geological Survey Open File Report 80-1265, 4 p.

Popenoe, P., B. Butman, C.K. Paull, M.M. Ball, and S. Pfirman. 1980. Interpretation of graphic data on potential geologic hazards on the southeastern United States Atlantic continental shelf. U.S. Geological Survey Miscellaneous Field Investigations MF-1276, 4 sheets.

Popenoe, P. and P.R. Pinet. 1980. The Upper Cretaceous clastic shelf edge off Georgia and South Carolina and the origin of the Charleston Bump (abs.). Geological Society of America, Abstracts with Programs 12(7):501.

Woo, C.C., O.H. Pilkey, and L.J. Doyle. 1978. Authigenic heavy minerals of the continental slope sediments off the eastern United States (abs.). Geological Society of America, Abstracts with Programs 10(7):519.

Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31
MU6-29
MU6-56
MU8-21
MU8-24
MU9-04
MU9-08/29166

BLM INTERAGENCY AGREEMENT NO.: AA551-MU9-8
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29166

Title: Marine Habitat Mapping and Pipeline Hazard Assessment of the South Atlantic OCS

Date: 15 January 1979 - January 1982

Cost: $453,521

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)
University of Georgia (UG)
University of South Florida (USF)
Duke University (DU)
Lamont-Doherty Geological Observatory (LD)

Program Manager:
Peter Popenoe

Principal Participants:
Bradford Butman (USGS)
Paul Bowker (USGS)
Dale Chayes (LD)
Elizabeth Coward (USGS)
C.J. McCreey (UG)
Larry Doyle (USF)
F.D. Foley (UG)
R.T. Giles (UG)
Vernon J. Henry (UG)
D.R. Kendall (UG)
Frank T. Manheim
T.H. McKissack (UG)
Marshall Otter (USGS)
Orrin Pilkey (DU)
William B.F. Ryan (LD)

Contracting Officer:
Paul Lubetkin
Carroll D. Day

COTR: Elwyn D. Wood
Murray Brown
Mark Grussendorf

Key Words:
pipelines, oil and gas; hazards-geologic sediment characteristics; geology-general treatment; sediments (geology); transport-sediments

Objectives:

1. Determine the distribution, areal extent, and vertical characteristics of geological features supportive of biological communities via sidescan sonar, seismic reflection/precision depth recorder, and towed underwater TV (Ocean Bottom Survey of the Georgia Bight).

2. Study the shelf near areas of oil and gas interest and possible pipeline corridors for evidence of geological instability (Pipeline Corridor and Regional Hazards Assessment-Sale No. 56).

3. Develop methodology by which barium in sediment samples can be determined faster and more economically than by the presently accepted neutron activation analysis (Barium Determination in Sediment).

4. Obtain information on the cause and effect relationship of bottom currents and storm surges to sediment and seston mobility (Bottom Sediment Mobility).

Final Report:

Data from this contract have been interpreted and synthesized in the final report of Contract No. IA2-26.

Final report ocean bottom survey of the U.S. South Atlantic OCS Region. (Henry, V.J.; 1983). Unpublished report submitted to Minerals Management Service, June 1983, 99 p: 5 Appendices containing cruise reports, data acquisition inventory, supplementary reports, data map series, and shelf atlases.

Other Publications/Reports:

Barans, C.A. and V.J. Henry, Jr. 1984. A description of the shelf edge groundfish habitat along the southeastern United States. Northeast Gulf Science 7(1):77-96.

Bowker, P.C., and F.T. Manheim. 1979. Barium and strontium determination in sediments (abs.). National Conference on Spectrochemical Excitation and Analyses Program, Groton, Conn., August 27-28, 1979.

_______________. 1982. Analysis of barium and strontium in sediments by dc plasma emission spectrometry. Applied Spectroscopy 36(4):378-382.

Coward, E.L., P. Popenoe, and M.L. Otter. 1980. Miocene-Pliocene unconformity on the Blake Plateau (abs.). Geological Society of America, Abstracts with Programs 12(7):409.

Freeman-Lynde, R.P., P. Popenoe, and F.W. Meyer. 1982. Seismic stratigraphy of the western Straits of Florida (abs.). Geological Society of America, Abstracts with Programs 14(1-2):18.

Henry, V.J. and R.T. Giles. 1979. Distribution and occurrence of reefs and hardgrounds in the Georgia Bight (abs.). Geological Society of America, Abstracts with Programs 11(4):182.

Idris, F.M. 1983. Shallow structure and stratigraphy of the U.S. South Atlantic shelf between Savannah, Georgia and Cape Romain, South Carolina. Ph. D. Dissertation under the direction of Dr. V.J. Henry. Athens, GA: University of Georgia.

Kellam, J.A. 1981. Neogene seismic stratigraphy and depositional history of the Tybee Trough area, Georgia/South Carolina. Master's thesis under the supervision of V.J. Henry. Athens, GA: University of Georgia.

Manheim, F.T. and P.C. Bowker. 1980. Analysis of barium in sediments: U.S. Geological Survey Open File Report 80-665, 19 p.

Manheim, F.T., P. Popenoe, W. Siapno, and C. Lane. 1982. Manganese-phosphorite deposits of the Blake Plateau (western North Atlantic Ocean). In: Marine minerals deposits--new research results and economic prospects: Proceedings of the Clausthaler Workshop held in September 1982. Halbach, P. and P. Winter (eds.). Marine Rohstoffe und Meerestechnik 6:9-44.

Pinet, P.R. and P. Popenoe. 1982. Surface circulation in the western North Atlantic Ocean during Mesozoic and Cenozoic time (abs.). Geological Society of America, Abstracts with Programs 14(7):588-589.

Popenoe, P. 1982. The Middle Tertiary origin of Albemarle Sound, North Carolina (abs.). Geological Society of America, Abstracts with Programs 14(1-2):591.

Popenoe, P. 1983. High resolution seismic reflection profiles collected August 4-28, 1979, between Cape Hatteras and Cape Fear, North Carolina, and off Georgia and northern Florida. U.S. Geological Survey Open File Report 83-512, 4 p.

Popenoe, P. 1984. Cenozoic depositional and structural history of the North Carolina margin from seismic stratigraphic analyses. In: Stratigraphy and depositional history of the U.S. Atlantic margin. Poag, C.W.(ed.). Stroudsburg, PA: Van Nostrand Reinhold Publishing Company, pp. 125-183, 43 figs., 4 plates.

Popenoe, P. 1985. A summary of environmental geologic studies on the southeastern United States Atlantic Outer Continental Shelf, 1979-1982. U.S. Geological Survey Open File Report 85-(in press).

Popenoe, P. 1985a. Depositional and structural history of the Southeast Georgia Embayment and Suwannee Straits from seismic stratigraphic analyses. Geological Society of America, Abstracts with Programs 17(2):129.

Popenoe, P. 1985b. Seismic stratigraphy of sinkholes and the boulder zone under the northeastern Florida continental shelf. Geological Society of America, Abstracts with Programs 17(2):129.

Popenoe, P., E.L. Coward, and K.V. Cashman. 1982. A regional assessment of potential environmental hazards to and limitations on petroleum development of the southeastern United States Atlantic continental shelf, slope, and rise, offshore North Carolina. U.S. Geological Survey Open File Report 82-136, 67 p., map 1:1,000,000.

Popenoe, P., E.L. Coward, M.E. Vazzana, M.M. Ball, and D.W. Edsall. 1979. A high-resolution seismic survey of the Florida-Hatteras shelf and slope, and the Blake Plateau and Escarpment (abs.). Geological Society of America, Abstracts with Programs 11(4):209.

Popenoe, P., K.D. Klitgord, W.P. Dillon, P.R. Pinet, and J.A. Grow. 1982. Structure and history of the Carolina Platform (Cape Fear Arch) (abs.). Geological Society of America, Abstracts with Programs 14(1-2):74.

Popenoe, P., F.A. Kohout, and F.T. Manheim. 1984a. Buried sinkholes and karst in the Florida offshore from seismic reflection studies. Proceedings of the First Multidisciplinary Conference on Sink Holes, Orlando, Florida. 1 p.

___________. 1984b. Seismic reflection studies of sinkholes and limestone dissolution features on the northeastern Florida shelf. In: Sinkholes, their geology, and engineering and environmental impact. Beck, B.F. (ed.). Boston, MA: A.A. Balkema Publishing Company. pp. 43-57.

Slater, R.A., D.W. Folger, B. Butman, M.H. Bothner, H.J. Knebel, J.A. Aaron, J.M. Robb, and P. Popenoe. 1979. Potential geologic hazards associated with the United States Atlantic continental margin. In: Offshore geologic hazard short-course notes. Houston, TX: Rice University. pp. 4-1 to 4-48.

Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31
MU6-29
MU6-56
MU8-13
MU8-21
MU8-24
MU9-04
MU9-08/29166

BLM INTERAGENCY AGREEMENT NO.: AA851-MU0-16
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29175

Title: South Atlantic OCS-Blake Plateau Hazards Mapping Study (South Atlantic Geological Program, Year 4)

Date: 24 June 1980 - January 1982

Cost: $596,020
$159,000
$755,020

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
University of Georgia (UG)
Colgate University (CU)
Duke University (DU)
University of South Florida (USF)

Program Manager:
Peter Popenoe

Principal Participants:
Kathy V. Cashman
Elizabeth L. Coward
L.J. Doyle (USF)
Vernon J. Henry, Jr. (UG)
T.H. McKissack (UG)
O.H. Pilkey (DU)
Paul Pinet
Edith Williams

Contracting Officer:
Carroll Day

COTR: Mark Grussendorf
Murray Brown
Eiji Imamura

Key Words:
hazards-geologic sediment characteristics; geology-general treatment; ecological characteristics

Objectives:

1. Conduct a stratigraphic study to determine the overall subbottom structure of the sedimentary sequence on the shelf, slope, Blake Plateau and Escarpment offshore of North Carolina.

2. Conduct a geohazards evaluation to identify those structures or features which could pose a hazard to oil

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and gas operations on the South Atlantic Outer Continental Shelf (OCS).

3. Conduct a sensitive biological communities study to determine the distribution, areal extent, and vertical characteristics of geological features supportive of biological communities on the Florida-Hatteras Shelf off North Carolina.

4. Continue efforts to compile and synthesize data for the Geological Atlas series for "Jacksonville" and "Brunswick" areas.

Final Report:

Data from this contract have been interpreted and synthesized in the final report of Contract No. IA2-26.

Other Publications/Reports:

Barans, C.A. and V.J. Henry, Jr. 1984. A description of the shelf edge groundfish habitat along the southeastern United States. Northeast Gulf Science 7(1):77-96.

Butman, B. and R.C. Beardsley. 1986. Long-term observations on the southern flank of Georges Bank. Part I: A description of the seasonal cycle of currents, temperature, stratification, and wind stress. Journal of Physical Oceanography 17(3):367-384.

Cashman, K.V. and P. Popenoe. 1985. Slumping and shallow faulting related to the presence of salt on the continental slope and rise off North Carolina. Marine and Petroleum Geology 2:260-271.

Cashman, K.V., P. Popenoe, and D. Chayes. 1981. Sidescan sonar depiction of slump features associated with diapirism on the continental slope off the southeastern United States (abs.). American Association of Petroleum Geologists Bulletin 65(5):909.

Cashman, K.V., P. Popenoe, and J.A. Grow. 1980. Salt diapirs and related features on the southeastern U.S. continental margin as viewed by long-range sidescan sonar (abs.). Geological Society of America, Abstracts with Programs 12(7):400.

Grow, J.A., W.P. Dillon, and P. Popenoe. 1979. Diapirs along the continental slope southeast of Cape Hatteras (abs.). Geological Society of America, Abstracts with Programs 11(4):181.

Henry, V.J. and F.D. Foley. 1981. Bottom morphology and shallow subbottom sedimentary structures on the U.S. continental shelf between Cape Hatteras, North Carolina, and Jacksonville, Florida. AAPG/SEPM Atlantic Margin Energy Conference, Atlantic City October 4-6, 1981.

Henry, V.J. 1983. Final report ocean bottom survey of the U.S. South Atlantic OCS Region: Report submitted to Minerals Management Service, June 1983, 99 p., and 5 Appendixes containing

cruise reports, data acquisition inventory, supplementary reports, data map series, and shelf atlases. Appendix 5 submitted June 12, 1984, includes: Atlas Series Maps of Geohazards and Reefs and Hardgrounds for Brunswick and Jacksonville quadrangles, scale 1:250,000.

Paull, C.K. and W.P. Dillon. 1980. The appearance and distribution of the gas hydrate reflection off the southeastern United States. U.S. Geological Survey Open File Report 80-88, 8 p.

______________. 1981. The appearance and distribution of the gas hydrate reflection off the southeastern United States. U.S. Geological Survey Miscellaneous Field Studies Map MF-1252.

Popenoe, P. 1984. Cenozoic depositional and structural history of the North Carolina margin from seismic stratigraphic analyses, In: Stratigraphy and depositional history of the U.S. Atlantic margin. Poag, C.W., (ed.). Stroudsburg, PA: Van Nostrand Reinhold Publishing Company, pp. 125-183, 43 figs. 4 plates.

Popenoe, P. 1985. A summary of environmental geologic studies on the southeastern United States Atlantic Outer Continental Shelf, 1979-1982: U.S. Geological Survey Open File Report 85-(in press).

Popenoe, P., K.V. Cashman, D. Chayes, and W.B.F. Ryan. 1981. Mid-range sidescan-sonar images covering parts of proposed tracts for OCS Lease Sale 56 and contiguous areas, Manteo, Cape Fear, and adjacent quadrangles off North Carolina. U.S. Geological Survey Open File Report 81-554, 6 p.

Popenoe, P., K.V. Cashman, and E.L. Coward. 1981. Environmental considerations for OCS development, Lease Sale 78 call area. In: Summary report on the regional geology, environmental considerations for development, petroleum potential, and estimates of undiscovered recoverable oil and gas resources of the United States southeastern Atlantic continental margin in the area of Oil and Gas Lease Sale no. 78. W.P. Dillon (ed.). U.S. Geological Survey Open File Report 81-749, pp. 59-98.

Popenoe, P., E.L. Coward, and K.V. Cashman. 1982. A regional assessment of potential environmental hazards to and limitations on petroleum development of the southeastern United States Atlantic Continental Shelf, slope, and rise, offshore North Carolina: U.S. Geological Survey Open File Report 82-136, 67 p., map 1:1,000,000.

Popenoe, P., W.P. Dillon, C.K. Paull, and J.M. Robb. 1982. Environmental considerations. In: Summary of regional geology, petroleum potential, resource assessment and environmental considerations for Oil and Gas Lease Sale Area 56. W.P. Dillon (ed.). U.S. Geological Survey Open File Report 82-398, pp. 35-54.

Popenoe, P. and F.W. Meyer. 1983. Description of high-resolution seismic reflection data collected from the shelf, slope, and upper rise between Cape Hatteras, North Carolina, and Norfolk, Virginia; and Vero Beach to Miami, Florida. U.S. Geological Survey Open File Report 83-515, 4 p.

Other Related Contracts Within This Study Program:

IA2-26/29196
MU6-56
MU8-13

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BLM INTERAGENCY AGREEMENT NO.: AA851-IA1-15
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29183

Title: Hazards Mapping Study (South Atlantic Geological Program, Year 5)

Date: 4 March 1981 - August 1983

Cost: $324,464

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institution:
University of Georgia (UG)
Duke University (DU)

Program Manager:
Peter Popenoe

Principal Participants:
Kathy V. Cashman (GS)
Francisco Chavez (DU)
Vernon J. Henry, Jr. (UG)
Paul Pinet

Contracting Officer:
Carroll D. Day
Jeffrey Petrino

COTR: Murray Brown
Eiji Imamura

Key Words:
hazards-geologic sediment characteristics; sediments (geology); benthic studies; geophysical data

Objectives:

1. North Carolina Offshore Surficial Geology-Benthos Coupling Study. Synthesize available data and reports on the benthic communities offshore of North Carolina, together with geological data on surficial sediments and topography, into a working document for use by Minerals Management Service (MMS) (effort discontinued).

2. Geohazards and Geophysical Data Management and Interpretation Study. Complete the reduction of existing seismic and side-scan data into hazards maps and reports.

3. Marine Geologic Atlas Series Study. Update and continue the synthesis of all data obtained from the ocean bottom surveys in FY 1977-'78-'79-'80 with all other available data for the "Brunswick" and "Jacksonville" areas.

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Final Report:

Data from this contract have been interpreted and synthesized in the final report of Contract No. IA2-26.

Other Publications/Reports:

Behrendt, J.C., R.M. Hamilton, H.D. Ackerman, and V.J. Henry. 1981. Cenozoic faulting in the vicinity of the Charleston, South Carolina, 1886 earthquake. Geology 9(3):117-122.

Dillon, W.P., P. Popenoe, J.A. Grow, K.D. Klitgord, B.A. Swift, C.K. Paull, and K.V. Cashman. 1983. Growth faulting and salt diapirism: Their relationship and control in the Carolina Trough, eastern North America. In: Studies in continental margin geology. Watkins, J.S. and C.L. Drake (eds.). American Association of Petroleum Geologists Memoir 34, pp. 21-46.

Henry, V.J., L.J. Doyle, and P. Popenoe. 1982. Reefs and hardgrounds of the Georgia Bight: Research summary. In: Reefs and Hardgrounds Workshop, summary of results. Duke University Marine Laboratory, September 23-24, 1981. pp. 7-9.

Henry, V.J., J.A. Kellam, and F.D. Foley. 1982. Evidence for Quaternary sea level stillstands on the Georgia Bight continental shelf (abs.). Geological Society of America, Abstracts with Programs 14(1-2):24.

Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31
MU6-29
MU6-56
MU8-13
MU8-21
MU8-24
MU9-04
MU9-08/29166

South Atlantic

Physical Oceanography

BLM INTERAGENCY AGREEMENT NO.: AA551-IA6-03
BLM INTERAGENCY AGREEMENT NO.: AA551-IA8-37

Title: South Atlantic OCS Data Buoy, FY '76-'81

Date: January 1976 - 30 September 1981

Cost:

FY '76-'78	$152,600
FY '79	$117,400
FY '80	$ 81,000
FY '81	$101,600
TOTAL	$452,600

Prime Contractor:
National Oceanic and Atmospheric Administration (NOAA)
NOAA Data Buoy Office
NSTL Station, Mississippi 39529

Program Manager:
Kurt D. Zimmerman

Contracting Officer:
Paul Lubetkin
Carroll D. Day

COTR: Elwyn D. Wood
Richard E. Defenbaugh

Key Words:
meteorology; wind data/studies; atmospheric conditions

Objectives:

1. Deploy, operate, and maintain a meteorological monitoring buoy network for the South Atlantic Outer Continental Shelf, consisting of three buoys operating in a fully automatic mode in the following locations:

    a. off Charleston, South Carolina (32°31'N, 78°40'W);
    b. off Jacksonville, Florida (30°16'N, 80°27'W); and
    c. off Savannah, Georgia (31°40'N, 79°40'W).

2. Acquire automatically, from the buoys, hourly data frames of the following parameters:

    a. wind direction and magnitude (5 meter level);
    b. air temperature (5 meter level);
    c. atmospheric pressure (surface);
    d. sea surface temperature (1 meter depth); and
    e. surface wave spectral coefficients.

Final Report:
None.

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Monthly data reports are on file at the Minerals Management Service, Herndon, Virginia.

BLM CONTRACT NO.: AA550-CT7-16

Title: South Atlantic OCS Physical Oceanographic Literature Synthesis, FY 1977

Date: February 1977 - July 1979

Cost: $177,648

Prime Contractor:
Environmental Research and Technology, Inc. (ERT)
699 Virginia Road
Concord, Maine 01742

Subcontractors/Cooperating Institutions:
Clemson University (CU)
North Carolina State University (NCS)
University of Miami (UM)
Virginia Institute of Marine Science (VIMS)
Duke University Marine Laboratory (DUML)
Nova University (NU)

Program Manager:
Paul H. Kirshen

Principal Participants:

Richard Barber (DUML)	Thomas Lee (UM)
Harold Bernard	Joel Narod
James Bowley	Leonard Pietrafesa (NCS)
David Brooks (NCS)	Robert Weisberg (NCS)
Thomas Curtin (NCS)	Christopher Welch (VIMS)
Bill Edge (CU)	Jan Witte (NU)

Contracting Officer:
Paul Lubetkin

COTR: Elwyn D. Wood

Key Words:
circulation/current study; meteorology; literature search (bibliography); wind data/studies

Objectives:

1. Identify and assemble recent oceanographic and meteorological data not available from the National Oceanographic Data Center (NODC) or National Climatic Center (NCC) for the South Atlantic region.

2. Organize the data on tapes in formats that are compatible with NODC/NCC and transmit them to NODC/NCC.

3. Update a previously prepared National Science Foundation (NSF) bibliography for the region.

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4. Use recent previously catalogued data to describe, display, analyze, and interpret oceanographic and meteorological phenomena in the region.

5. Make recommendations for future sampling and buoy sites and programs based on the preceding analyses and a review of raw data and unworked samples.

Summary:

This report represents the synthesis and analysis of the physical oceanographic and meteorological data on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. Numerous information sources were searched to obtain an analysis of the climatology, wave data, hydrography, and the circulation of the continental shelf waters, all of which are crucial to platform construction, safety procedures, and management decisions. Seasonal variations of air temperature, wind speed and wind direction, cloud cover, cloud ceilings, visibility, precipitation, storms, weather fronts, solar radiation and precipitation run-off are discussed and summarized. Several programs are currently in progress to better define the physical oceanography and meteorology of the Outer Continental Shelf (OCS) study area.

A survey of climatological data was performed. In general, the OCS area is controlled by cyclonic (large-scale low pressure storms) activity in the winter and anti-cyclonic (high pressure) activity in the summer. In the winter the maximum of wind speeds, cloud cover, large-scale precipitation (that is, precipitation covering a large area) and low ceilings and visibilities occurs. In the summer the minimum of wind speeds, low cloud ceilings and visibilities occurs and the precipitation pattern changes to small-scale convective (that is, showers or thunderstorms). The mean daily precipitation reaches a minimum in spring and autumn.

Studies of the circulation of continental shelf water have shown that from about mid-shelf to the near-shore waters, tide- and wind-generated currents tend to produce most of the current variations. The tides are more influential on trans-shelf motions. The winds are more influential along the shelf fluctuations. The wind events generate horizontal east-west meanders of the western edge of the Gulf Stream.

Final Report:

Summary and analysis of physical oceanographic and meteorological information on the continental shelf and Blake Plateau from Cape Hatteras to Cape Canaveral. (ER&T; 1979).

Availability:

Available from NTIS:

Executive Summary (Vol. I) - PB80-159072
Final Report (Vol. II) - PB80-159080
Final Report (Vol. III) - PB80-159098

BLM INTERAGENCY AGREEMENT NO.: AA551-IA8-39

Title: South Atlantic OCS Satellite Oceanography

Date: 29 August 1978 - 24 September 1980

Cost: $150,000

Prime Contractor:
National Aeronautics and Space Administration (NASA)
Wallops Flight Center
Wallops Island, Virginia 23337

Subcontractors/Cooperating Institutions:
EG&G Washington Analytical Group (EGG)
Applied Science Associates, Inc. (ASA)

Program Manager:
Norden Huang

Principal Participants:
Clifford D. Leitao (NASA)
C.L. Parsons (NASA)
C.G. Parra (EGG)
J.D. McMillan (EGG)
G.S. Hayne (ASA)

Contracting Officer:
Paul Lubetkin
Carroll Day

COTR: Elwyn D. Wood

Key Words:
circulation current study; satellite-tracked drifters; current measurements, meters, drifters; wind data/studies

Objectives:
The main program objectives are to develop methodology for the use and interpretation of radar satellite altimeter data to estimate:

1. geostrophic ocean current position and velocity;
2. significant wave height (SWH); and
3. surface wind speed.

These estimates were concentrated in the South Atlantic Bight in order to define Gulf Stream characteristics in that area more completely.

Summary:
The analysis of long-term altimeter data to obtain sea surface topographies led to the following conclusions. The mean surface

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topographic maps should be evaluated with extreme caution, due to the various uncertainties in geoid, orbit, and intrinsic noises. The accuracy of the geoid was the most critical element because the geoid anomalies may have the same wavelength as ocean dynamic phenomena, and the geoid signal magnitude can also be much higher. The difference between the long-term (three years) and short-term (one month) means revealed changes of Gulf Stream path, and some eddy movements. In principle, the uncertainty of the geiod should not have been a problem here, but it did cause difficulty because of the data density from the altimeter. The long-term mean was produced by using the average of all the adjusted heights within a 1/2 degree square, and there could have been considerable geoid change within such an area. The averaging process reduced the true variations.

It was apparent that seasonal and annual variations in significant wave height and wind speed were readily detectable using waveform data from satellite radar altimetry, this was demonstrated with Geodetic Experimental Ocean Satellite (GEOS-3) measurements taken over the South Atlantic Bight during the study. Different degrees of spatial and temporal averaging were used to avoid under sampling. Some differences in the resultant wind speed distributions were found to agree with the known climatology of the area, on the smallest spatial scale tested. No wave height spatial difference was detected, as expected, given the low wave heights found in the South Atlantic Bight.

Final Report:

Final report of GEOS-3 radar altimeter study for the South Atlantic Bight. (NASA Tech. Memorandum 73286, 43 p. + appendices). (C.D. Leitao, N.E. Huang, C.L. Parsons, C.G. Parra, J.D. McMillan, G.S. Hayne; 1980).

Availability:

Available from NTIS: PB80-N 26023

Other Publications/Reports:

Huang, N.E., 1979. On surface drift currents in the ocean. Journal of Fluid Mechanics 91:191-208.

Huang, N.E. and C.D. Leitao, 1978. Large-scale Gulf Stream frontal study using GEOS-3 radar altimeter data. Journal of Geophysical Research 83:4672-4682.

BLM CONTRACT NO.: AA550-CT7-29
MMS CONTRACT NO.: 14-12-0001-29133

Title: South Atlantic Physical Oceanography Study (SAPOS), Year 1

Date: 20 May 1977 - July 1979

Cost: $1,318,729

Prime Contractor:
Science Applications, Inc. (SAI)
4900 Waters Edge Drive, Suite 255
Raleigh, North Carolina 27606

Subcontractors/Cooperating Institutions:
North Carolina State University (NCS)
University of Miami (UM)

Program Manager:
Paul Debrule

Principal Participants:
Otis Brown (UM)
Thomas Curtin (NCS)
Tom Lee (UM)
J. Fernandez-Partagas (UM)
Len Pietrafesa (NCS)
D. Tung (NCS)
Van Waddell (SAI)

Contracting Officer:
J.A. Rourke
Paul Lubetkin
Carroll D. Day

COTR: Elwyn D. Wood

Key Words:
circulation/current study; current measurements, meters, drifters; meteorology

Objectives:

1. Predict the dispersal, dilution, flushing, and final distribution of hydrocarbons and other pollutants that may be introduced into the marine environment as a result of Outer Continental Shelf (OCS) related oil and gas activities.

2. Provide information necessary to understand the biological and chemical systems in the Georgia Embayment and the effects of hydrocarbons and other pollutants on these systems.

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It is expected that a period of three years, plus about one year for the production of a final report, will be required to achieve the program objectives [Modified to 5-year program under Contract CT8-52]. First year objectives were to:

1. Describe the surface movement across the turbid-clear water zone.

2. Determine the short term (days to several weeks), vertical current structure near the shelf edge.

3. Characterize the seasonal variations in shelf water masses and short term variations in shelf edge water mass.

4. Correlate Georgia Embayment meteorological and sea state data with coastal meteorological data, National Weather Service (NWS) predictions, and with satellite photographs (e.g., LANDSAT - Band 5 photographs).

5. Investigate the effect of Gulf Stream intrusions on shelf water masses.

6. Determine the long-term (one year), multi-level current pattern at one location on the continental shelf.

The first step in meeting these goals was the evaluation of existing data on the physical oceanography of the South Atlantic OCS/Georgia Embayment and Blake Plateau areas. Under separate contract, all existing data will be summarized, synthesized, and evaluated with respect to overall program goals. Data gaps were determined and recommendations for filling the gaps were made for consideration in design of the continuing field effort.

Summary:
The final progress report represents the results of the first year of a 4-year physical oceanographic and meteorological data collection effort on the (OCS) from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, during the period of September 1977 through November 1978. The report is to be used to provide an understanding of the currents, circulation, and mixing processes in the Georgia/Embayment/South Atlantic Bight (SAB) to assess the effects of OCS oil and gas activities on the biological environment, as well as on recreational and commercial fishing. This program will eventually lead to analytical and numerical estimation (modeling) of the SAB physical oceanography.

Surface pollutants are influenced by both currents and winds. Movement is a weighted vector sum of the two forces. Vertical mixing and discharge plumes is common, however, the pycnocline inhibits complete vertical mixing. Tidal conditions are primary factors in plume behavior affecting convergence intensity, degree of vertical and lateral spreading, and intensity of density gradients. The data provide hydrographic information that was previously unavailable.

Subsurface velocity data were not collected, therefore, quantitative evaluation of pollutant behavior could not be determined.

Gulf Stream events (e.g., eddies) appear to dictate temporal changes in flow and temperature near the shelf break. Long-term time series of the Gulf Stream western edge are essential to understanding Georgia Embayment frontal variability. Monitoring may be accomplished by satellite thermal imagery which gives accurate surface thermal maps. Continued collection of wind and wave data provides baseline information to establish statistical models of these processes and the probable effect on offshore structures.

Final Report:

South Atlantic OCS physical oceanography final progress report (first year). (SAI; 1979).

Availability:

Available from NTIS:
- Executive Summary (Vol. I) - PB80-181548
- Final Report (Vol. II) - PB80-181555
- Final Report (Vol. III) - PB80-181563
- Final Report (Vol. IV, Bk. 1) - On file at Minerals Service, Herndon, Virginia
- Final Report (Vol. IV, Bk. 2) - on file at Minerals Management Service, Herndon, Virginia

Other Publications/Reports:

(See Year 5. CT2-61)

Other Related Contracts Within This Study Program:

CT0-12/29173
CT1-25/29186
CT2-61/29201
CT8-52/29138 ACT NO. AA551-CT8-52

MMS CONTRACT NO.: 14-12-0001-29138

Title: South Atlantic Physical Oceanography Study (SAPOS), Year 2

Date: 29 September 1978 - March 1981

Cost: $1,184,404

Prime Contractor:
Science Applications, Inc. (SAI)
4900 Waters Edge Drive, Suite 255
Raleigh, North Carolina 27606

Subcontractors/Cooperating INstitutions:
Nova University (NU)
University of Miami (UM)
North Carolina State University (NCS)
Skidaway Institute of Oceanography (SIO)

Program Manager:
Paul Debrule
Evans Waddell

Principal Participants:
Larry Atkinson (SIO)
Phil Bedard (NU)
Otis Brown (UM)
Tom Curtin (NCS)
Peter Hamilton (SAI)
Len Pietrafesa (NCS)
James Yoder (SIO)

Contracting Officer:
Paul Lubetkin
Carroll Day

COTR: Elwyn D. Wood

Key Words:
circulation/current study; meteorology; hydrographic, salinity, temperature data; current measurements, meters, drifters

Objectives:
The objective of this study was to quantify parameters needed to describe and model the Georgia Embayment/South Atlantic Outer Continental Shelf (SAOCS) region circulation and mass transport characteristics. This was a 5-year program; specific tasks for year two included:

1. Surface Currents. Deploy five radio equipped surface drogues from 5 to 14 days.

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2. Subsurface Currents. Deploy one cross-shelf transect of three moorings (one year-round, the others winter and summer only).

3. Hydrography. Conduct four seasonal cruises of six transects each from Cape Fear to Cape Canaveral.

4. Gulf Stream (GS) Variability. Determine monthly GS surface characteristics using VHRR imagery.

5. Shelf Forcing Mechanisms. Obtain data from NDBO buoys, Savannah River Tower and NWS/NCC sources.

6. Meetings. Coordinate and conduct three SA OCS studies meetings.

7. MOD 1. Expand the geographic region of the hydrographic task north to Cape Hatteras and out to cross Gulf Stream. Deploy up to 12 drifters off Cape Hatteras, analyze chlorophyll a data, and include a fourth meeting.

8. MOD 2. Extend the period of performance and replacement costs for VACM (Nova University).

Summary:
Studies in the South Atlantic Bight (SAB) Outer Continental Shelf (OCS) were initiated to provide information for development and evaluation of acceptable operational procedures and to make management decisions. One component of this program is the Physical Oceanography Study which was designed to provide a description and understanding of circulation and mixing in the SAB/OCS, as well as an understanding of the nature and relative importance of forcing mechanisms.

The Final Report presents a summary of field activities and analyses of physical oceanographic and meteorological data collected on the OCS from Cape Fear, North Carolina, to Cape Canaveral, Florida during the period of November 1978 through February 1980. Study results of Year II indicate:

1. Over and along the SAB shelf, winds are similar. However, winter winds are stronger and vary regularly. Winds occurring away from the coast are generally stronger than those at the coast, and there appears to be a systematic relationship between winds measured near the coast and those measured at mid-shelf locations.

2. The western boundary of the Gulf Stream migrates on and offshore with the larger magnitude motion occurring from the Charleston Bump northward.

3. Gulf Stream Western Boundary (GSWB) events (eddies and filaments) are a major factor in lateral motion of the

GSWB. These events have major importance to flushing, hydrography, and primary productivity in the SAB shelf.

4. GSWB events account for most of the observed subsurface current fluctuations on the outer shelf. On the mid to inner shelf, tides and the effects of wind stress are the mechanisms which dominate observed subsurface currents.

5. Surface water can be exchanged across the GSWB. This can be a one or two direction movement.

The general conclusions of the study indicate circulation of the SAB OCS is the result of winds, water level fluctuations, and Gulf Stream related events (e.g., eddies), all of which are closely interrelated. Zones along the shelf can be identified by the mechanisms controlling circulation; the outer shelf dominated by Gulf Stream events (e.g., meanders), and the mid-shelf and inner-shelf where tides and direct wind account for most current fluctuations. Current data support the hypothesis that shelf proper circulation may be explained by the Ekman equilibrium model.

Upwellings of nutrient rich water into the euphotic zone for biological uptake are predominantly caused by Gulf Stream events. Upwelling can result in locally high primary productivity and may be a more important nutrient source than continental runoff.

Surface currents within the Gulf Stream events have not been adequately explained. Further research is necessary to document circulation patterns (surface and subsurface currents) in areas of potential oil and gas leasing to allow proper impact assessment.

Final Report:

South Atlantic OCS Physical Oceanography (Second Year). (SAI; 1981).

Availability:

Available from NTIS:

Executive Summary	PB82-141862
Technical Report	PB82-141870
Data Products (1)	PB82-141888
Data Products (2)	PB82-141896

Other Publications/Reports:

(See Year 5, CT2-61)

Other Related Contracts Within This Study Program:

CT0-12/29173
CT7-29
CT1-25/29186
CT2-61/29201

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BLM INTERAGENCY AGREEMENT NO.: AA551-IA9-24

Title: The Collection of Physical Oceanographic Information on the South Atlantic Outer Continental Shelf

Date: 27 September 1979 - September 1980

Cost: $60,400

Prime Contractor:
U.S. Department of Energy (DOE)

Program Manager:
George Saunders

Contracting Officer:
Carroll Day

COTR: Elwyn D. Wood

Key Words:
circulation/current study; meteorology; hydrographic, salinity, temperature data; current measurement, meters, drifters

Objectives:
To collect physical oceanographic and hydrographic data on the South Atlantic OCS.

Final Report:
None: 12 days of ship time for data collection only.

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BLM CONTRACT NO.: AA851-CT0-12
MMS CONTRACT NO.: 14-12-0001-29173

Title: South Atlantic Physical Oceanography Study (SAPOS), Year 3

Date: 28 March 1980 - October 1982

Cost: $1,079,505

Prime Contractor:
Science Applications, Inc. (SAI)
4900 Water's Edge Drive, Suite 255
Raleigh, North Carolina 27606

Subcontractors/Cooperating Institutions:
Skidaway Institute of Oceanography (SIO)
North Carolina State University (NCS)
University of Miami (UM)

Program Manager:
Evans Waddell

Principal Participants:
Larry Atkinson (SIO)
Philip Bedard (UM)
Otis Brown (UM)
Thomas Curtin (NCS)
Peter Hamilton (NCS)
Thomas Lee (UM)
Joe Karpan (SAI)
R. Weisburg (SAI)

Contracting Officer:
Carroll D. Day
Jeffrey P. Petrino

COTR: Elwyn D. Wood
Murray Brown
William H. Lang

Key Words:
circulation/current study; current measurements, meters, drifters; hydrographic, salinity, temperature data; meteorology

Objectives:
The objective of this study was to quantify parameters needed to describe and model the South Atlantic Outer Continental Shelf (OCS) circulation and mass transport characteristics. This is a 5-year program. Specific tasks for year three include:

1. Subsurface Current Measurements. Deploy three moorings off Cape Romain during the GABEX I experiment (Feb.-June 1980).

2. Hydrography. Two hydrographic cruises for Blake Plateau (18 days) and North Carolina OCS (97 days).

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3. Shelf Forcing Mechanisms. Obtain data from NDBO Buoys 41003, 41004, and 41005.

4. Gulf Stream Variability. Use VHRR imagery to support GABEX I and develop statistics for (GSWB) locations.

5. Meetings. Coordinate and conduct meetings at Raleigh and Charleston.

6. MOD 1. Conduct a transfer function analysis for coastal to offshore winds and determine the future need for NDBO Buoys.

7. MOD 2. Add a winter North Carolina hydrographic cruise; increase VHRR image products; and prepare uniform hydrographic data sets from the benchmark contract (CT7-2), year 1 (CT7-29)/current meter data sets for CT7-29, CT8-52.

Summary:

Volume I (Executive Summary) provides a summary of field activities and analyses of physical oceanographic and meteorological data collected on the South Atlantic Bight/OCS and Blake Plateau from January 1980 to February 1981, during Year 3 of the Physical Oceanographic Study. Project objectives, study participants, technical summaries (of Volume II reports) and planned tasks for Years 4 and 5 are provided.

The Blake Plateau had dynamic multi-level processes resulting in surface and deep mixing of water masses with diverse and often remote source regions. South of the Charleston Bump, much of the dominant low frequency current fluctuations of mid-shelf locations were driven by wind induced cross-shelf sloping water surfaces (barotropic flow). On the outer shelf and within the Georgia Embayment, circulation, productivity, and flushing were intimately linked to stable and unstable waves forming along the Gulf Stream Western Boundary (GSWB). Data indicated the presence of a semipermanent meander in the annual mean position of the GSWB, downstream of the Charleston Bump. Coastal winds data can be transformed to estimate low frequency components of shelf winds. The Cape Hatteras region had complex conditions resulting from mixing of considerably different available water masses. Estimates of flushing rates varied as a function of season, and across and along shelf location.

Final Reports:

South Atlantic OCS Physical Oceanography Final Progress Report (Third Year). (SAI; 1982).

Availability:

Available from NTIS:
- Executive Summary (Vol. I.) - PB83-144386
- Technical Report (Vol. II) - PB83-144394
- Data Products (Vol. III, 2 pts) - PB83-144402 & PB83-144410

Other Publications/Reports:

Blanton, J.O., J.A. Yoder, L.P. Atkinson, T.N. Lee, C.R. McClain, D.W. Menzel, G.A. Paffenhofer, L.J. Pietrafesa, L.R. Pomeroy, and H.L. Windom. 1984. A multidisciplinary oceanography program on the southeastern U.S. continental shelf. EOS: Transactions, American Geophysical Union 65(49):1201-1204.

Leaman, K.D., T.N. Lee, and R.D. Findley. 1983. Performance of an experimental Aanderaa current meter modified for near-surface measurements. Marine Technology Society Journal 17(1):34-38.

Lee, T.N., E. Daddio, and G.C. Han. 1982. Steady-state diagnostic model of summer mean circulation on the Georgia shelf. Journal of Physical Oceanography 12(8):820-838.

Other Related Contracts Within This Study Program:

CT7-29
CT1-25/29186
CT2-61/29201
CT8-52/29138

BLM CONTRACT NO.: AA851-CT1-25
MMS CONTRACT NO.: 14-12-0001-29186

Title: South Atlantic Physical Oceanography Study (SAPOS), Year 4

Date: 3 March 1981 - February 1983

Cost: $537,921

Prime Contractor:
Science Applications, Inc. (SAI)
4900 Water's Edge Drive, Suite 255
Raleigh, North Carolina 27606

Subcontractors/Cooperating Institutions:
University of Miami (UM)
Skidaway Institute of Oceanography (SIO)
North Carolina State University (NCS)

Program Manager:
Evans Waddell

Principal Participants:
Larry Atkinson (SIO)
Otis Brown (UM)
Thomas Curtin (NCS)
Peter Hamilton (SAI)
Joe Karpen (SAI)
Thomas Lee (UM)
Len Pietrafesa (NCS)

Contracting Officer:
Carroll D. Day
Jeffrey P. Petrino

COTR: Elwyn D. Wood
Murray Brown
William H. Lang

Key Words:
circulation/current study; meteorology; current measurements, meters, drifters; hydrographic, salinity, temperature data

Objectives:
The objective of this study was to quantify parameters needed to describe and model the South Atlantic Outer Continental Shelf (OCS) circulation and mass transport characteristics. Specific tasks for year four included:

1. Measure cross-shelf currents on the shelf break and Gulf Stream in the region of Cape Hatteras.

2. Characterize shelf-forcing mechanisms through interpretation of meteorological data buoy information.

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3. Form an editorial review panel.

4. Initiate interpretation and synthesis of all data from the 4 years of field studies, and conduct two studies program meetings.

5. Conduct an OCS Reef and Hard Bottom Workshop.

Summary:

Results of the fourth year efforts of a 5-year program to study the physical oceanography of the South Atlantic are presented in three volumes. Volume I is an executive summary, presenting a brief summary of the study. Volume II is a detailed technical report presenting studies on the variability and range of Gulf Stream western boundary positions, effects of local wind stress on across-shelf transport and general circulation patterns, seasonal means and variance of hydrographic and current data, and a detailed analysis of forcing mechanisms and resulting circulation in the Georgia Embayment. Volume III is a compilation of fourth year field data not specifically utilized in Volume II reports and is primarily concerned with hydrographic data collected off North Carolina.

Data showed that the SAB Gulf Stream boundary can have fairly frequent and large (± 50 km) lateral excursions. Local wind stress generally had a dominant role in controlling set-up or set-down of coastal sea level, both in average conditions and extreme events (e.g., Hurricane David). Vertical stratification was strongly season dependent. In winter, stratification was weak, but increased toward spring (April) with increased air temperature and local availability of lower salinity water (i.e., runoff). By August, sensible and radiative heat flux into the water column combined with reduced wind mixing to produce maximum vertical stratification which could be intensified locally by upwelling. Shelf break upwelling associated with frontal eddies resulted in a large onshore transport of nutrients. Evaluating cumulative influence of a regular eddy passage indicated that nutrient flux related to shelf break upwelling may exceed riverine contribution by 7 to 10 times.

Final Report:

South Atlantic OCS physical oceanography final progress report (year four). (SAI; 1983).

Availability:

Available from the NTIS:
Executive Summary (Vol. I) - PB83-199497
Technical Report (Vol. II) - PB83-199505
Data Products (Vol. III) - PB83-199513

Other Publications/Reports:

Atkinson, L.P., D.W. Menzel, and K.A. Bush (eds.). 1985. Oceanography of the southeastern U.S. continental shelf. Coastal and Estuarine Sciences no. 2. Washington, DC: American Geophysical Union. 156 p.

Atkinson, L.P., J.A. Yoder, and T.N. Lee. 1984. Review of upwelling off the southeastern United States and its effect on continental-shelf nutrient concentrations and primary productivity. Rapports et Proces-Verbaux des Reunions. Conseil International pour l'Exploration de la Mer. 183:70-78.

Blanton, J.O., L.P. Atkinson, L.J. Pietrafesa, and T.N. Lee. 1981. The intrusion of Gulf Stream water across the continental shelf due to topographically-induced upwelling. Deep-Sea Research 28A(4):393-405.

Butman, B. and R.C. Beardsley. 1987. Long-Term observations on the southern flank of Georges Bank. Part I: A description of the seasonal cycle of currents, temperature, stratification, and wind stress. Journal of Physical Oceanography 17(3):367-384.

Kourafalou, V., J.D. Wang, and T.N. Lee. 1984. Circulation on the continental shelf of the southeastern United States. Part III: Modelling the winter wind-driven flow. Journal of Physical Oceanography 14(6):1022-1031.

Lee, T.N., V. Kourafalou, J.D. Wang, W.J. Ho, J.O. Blanton, L.P. Atkinson, and L.T. Pietrafesa. 1985. Shelf circulation from Cape Canaveral to Cape Fear during Winter. In: Oceanography of the southeastern U.S. continental shelf. L.P. Atkinson, D.W. Menzel, and K.A. Bush (eds.). Coastal and Estuarine Sciences, no. 2. Washington, DC: American Geophysical Union, pp. 33-62.

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Pietrafesa, L.J. G.S. Janowitz, and P.A. Wittman. 1985. Physical oceanographic processes in the Carolina capes. In: Oceanography of the southeastern U.S. continental shelf. L.P. Atkinson, D.W. Menzel, and K.A. Bush (eds.). Coastal and Estuarine Sciences, no. 2. Washington, DC: American Geophysical Union, pp. 23-32.

Wang, J.D., V. Kourafalou, T.N. Lee. 1984. Circulation on the continental shelf of the southeastern United States. Part II. Model development and application to tidal flow. Journal of Physical Oceanography 14(6):1013-1021.

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Other Related Contracts Within This Study Program:

CT0-12/29173
CT7-29
CT2-61/29201
CT8-52/29138

BLM CONTRACT NO.: AA851-CT2-61
MMS CONTRACT NO.: 14-12-0001-29201

Title: Completion of South Atlantic OCS Physical Oceanography Synthesis

Date: 29 September 1982 - October 1984

Cost: $423,755

Prime Contractor:

Science Applications, Inc. (SAI)
4900 Water's Edge Drive
Suite 255
Raleigh, North Carolina 27606

Subcontractors/Cooperating Institutions:

University of Miami (UM)
Skidaway Institute of Oceanography (SIO)
North Carolina State University (NCS)

Program Manager:

Evans Waddell

Principal Participants:

Larry Atkinson (SIO)
Otis Brown (UM)
Tom Curtin (NCS)
Peter Hamilton (SAI)
Tom Lee (UM)
Len Pietrafesa (NCS)

Contracting Officer:

Jeffrey Petrino

COTR: William H. Lang

Key Words:

circulation/current study; wind data/studies; hydrographic, salinity, temperature data

Objectives:

1. Complete data analysis of previous field studies for wind-forcing mechanisms, North Carolina and Blake Plateau hydrographic cruises, and current meter results from GABEX II/G.O. 35`N array.

2. Produce a final summary report for the entire South Atlantic Physical Oceanography Study (SAPOS) in a style which presents findings geared to a technical but non-specialist reader.

3. Prepare seven technical manuscripts for submission to professional journals or publications.

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Summary:
Between 1977 and 1984 a physical oceanographic field measurement and data interpretation and synthesis program was conducted for an area extending alongshore from approximately Cape Hatteras to Cape Canaveral and offshore across the shelf and the Blake Plateau. Emphasis was on shelf and shelf-break processes. Primary measurements made or used extensively in one or more program years include: subsurface currents/temperature, regional/seasonal hydrography, satellite thermal imagery, coastal water levels, and coastal and marine winds. The present program was closely coordinated with a concurrent Department of Energy (DoE) funded program which studied conditions on the shelf in the Georgia Embayment.

The Gulf Stream is the most significant forcing mechanism promoting South Atlantic Bight circulation. Associated boundary features such as meanders, filaments, and frontal eddies significantly affect shelf circulation. As it flows north the Gulf Stream parallels the continental slope. Despite the constant nature of the Gulf stream axis, the edges exhibit considerable influence on shelf circulation, transporting heat, mass, momentum, and nutrients. Meanders are lateral oscillations deflecting boundaries inshore (or offshore) 20 to 30 km. These lateral deflections are the result of long waves with periods ranging from 2 to 14 days. Crests from meander waves often drag a lens of warm Gulf stream water along behind. The thickness of this lens varied with location being 15-20 m deep in the Georgia Embayment, 60 to 100 m deep north of the Charleston Bump in the Carolina capes, and as deep as 600 m in the unbounded region off Cape Hatteras.

Wind induced circulation in the South Atlantic Bight was evident across the entire shelf. Principal wind systems are associated with mesoscale atmospheric pressure systems and fronts which traverse the area with a 2 to 14 day periodicity. On the inner shelf, higher frequency events such as sea breezes contribute ephemerally to circulation. Wind fields associated with major atmospheric fronts are similar across the entire area. Conversely, Gulf Stream events are migratory and influence successive downstream locations sequentially. Wind and tidal effects on inner shelf circulation are often superimposed on horizontal density gradients produced by estuarine discharges. Tidal currents mostly affect inner and middle shelf waters where direct Gulf Stream influence is minimal. Tidal periodicities are rapid when compared to wind induce variability. The dominant tidal component is the semidiurnal lunar tide with a maximum tidal range and current on the Georgia continental shelf. Tides were much less of a factor on the Carolina shelf than on the Georgia Shelf.

During summer, surface heating promotes vertical stratification of shelf waters. In fall, increased winds and cooler surface waters break down stratification and cause vertical mixing. By winter, the shelf waters are vertically uniform and horizontally stratified with the warmest waters being at or seaward od the shelf break. Inner shelf waters are increasingly colder from south to north. In spring,

increased surface temperature and reduced mixing again promote vertical stratification. This cycle also influences a seasonal mean sea level cycle with lower than mean values in winter and higher than mean sea level in summer. Movements of surface and deeper Gulf Stream waters onto the shelf by boundary events occur during all seasons. During summer, upwelling associated with boundary events bring cooler waters onto the outer shelf thus the new heat flux is offshelf. In winter, the net heat flux is onshore regardless of vertical or horizontal stratification.

Final Report:

South Atlantic physical oceanography study (Year 5). (SAI; 1984).

Availability:

Available from NTIS:
Executive Summary - PB84-187855
Final Report - PB84-187848

Other Publications/Reports:

Atkinson, L.P. 1983. Distribution of Antarctic Intermediate Water over the Blake Plateau. Journal of Geophysical Research 88(C8):4699-4704.

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Kourafalou, V., J.D. Wang, and T.N. Lee. 1984. Circulation on the Southeast U.S. continental shelf, part III - circulation model with application to the winter wind-driven flow. Journal of Physical Oceanography 14(6):1022-1031.

Leaman, K.D., T.N. Lee and R. Findley. 1983. Performance of an experimental Aanderaa current meter modified for near-surface measurements. Marine Technology Society 17(1):34-38.

Lee, T.N. and L.P. Atkinson. 1982. On Gulf Stream frontal eddies along the southeast U.S. Outer Continental Shelf. In: Workshop on Naval Gulf Stream Structure and Variability - Proceedings, Office of Naval Research. Research Triangle, NC, April 1982. pp. 182-222.

________________. 1983. Low frequency current and temperature variability from Gulf Stream frontal eddies and atmospheric forcing along the Southeast U.S. Outer Continental Shelf. Journal of Geophysical Research 88:4541-4567.

Lee, T.N., L.P. Atkinson and R. Legneckis. 1981. Observations of a Gulf Stream frontal eddy on the Georgia continental shelf, April 1977. Deep-Sea Research 28A:347-348.

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Lee, T.N., V. Kourafalou, J.D. Wang, W. Ho, J.O. Blanton, L.P. Atkinson, and L.J. Pietrafasa. 1985. Shelf circulation from Cape Canaveral to Cape Fear during winter. In: Oceanography of the southeastern U.S. continental shelf. L.P. Atkinson, D.W. Menzel, and K.A. Bush (eds.). Coastal and Estuarine Sciences, no. 2. Washington, DC: American Geophysical Union, pp. 33-62.

Lee, T.N., and E. Waddell. 1983. On Gulf Stream variability and meanders over the Blake Plateau at 30°N. Journal of Geophysical Research 88(C8):4617-4632.

Olson, D.B., O.B. Brown, and S.R. Emmerson. 1983. Gulf Stream derived from satellite and historical data. Journal of Geophysical Research 88:4569-4577.

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Wang, J.D., V. Kourafalou, and T.N. Lee. 1984. Circulation of the Southeast U.S. continental shelf, part II - model development and application to tidal flow. Journal of Geophysical Research 14(6):1013-1021.

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Yoder, J.A., L.P. Atkinson, S.S. Bishop, E.E. Hofmann, and T.N. Lee, 1983. Effect of upwelling on phytoplankton productivity of the outer southeastern United States continental shelf. Continental Shelf Research 1:385-404.

Other Related Contracts Within This Study Program:

CT0-12/29173
CT7-29
CT1-25/29186
CT8-52/29138

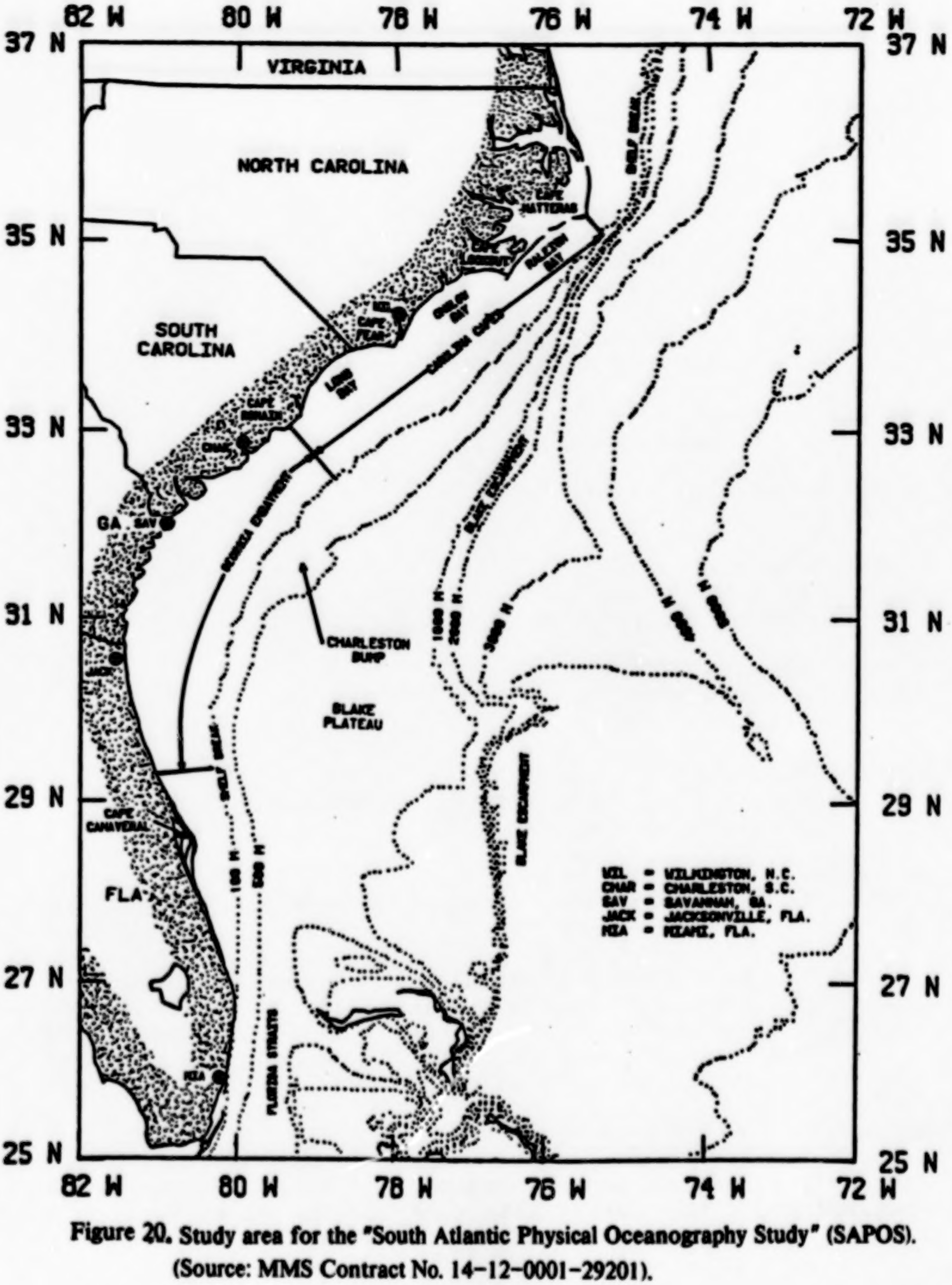

Figure 20. Study area for the "South Atlantic Physical Oceanography Study" (SAPOS). (Source: MMS Contract No. 14-12-0001-29201).

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BLM CONTRACT NO.: AA851-CT0-35
MMS CONTRACT NO.: 14-12-0001-29176

Title: Blake Plateau Bottom and Mid-Water Current Study, Year 1

Date: 27 May 1980 - September 1982

Cost: $359,319

Prime Contractor:
General Oceanics, Inc. (GOI)
1295 NW 163rd St.
Sunshine State Industrial Park
Miami, Florida 33169

Subcontractors/Cooperating Institutions:
University of Miami (UM)

Program Manager:
Chris Casagrande

Principal Participants:
Tom Lee (UM)

Contracting Officer:
Carroll D. Day
Jeffrey P. Petrino

COTR: Elwyn D. Wood
Murray Brown
William H. Lang

Key Words:
circulation/current study; circulation model; transport (physical processes)

Objectives:

1. Deploy five moorings along 30°N lat. (70-970 m) for one year.

2. Establish a physical oceanographic data base to provide both information for initializing and calibrating a prognostic numerical model of South Atlantic Bight/Blake Plateau processes, and independent estimates of key processes active in the area.

Summary:
General Oceanics, Inc., under a Minerals Management Service (MMS) (formerly Bureau of Land Management) contract, anchored five moorings instrumented with current meters across the Blake Plateau along latitude 30°N. The water depths range from 70 to 970 m.

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The data collected from the 12-month field study are to be used to verify the performance of a numerical model, also supported by the MMS, representing circulation in the South Atlantic Bight.

One current meter was placed near the anchor of each mooring. Two of the moorings intended for anchorage under the Gulf Stream had an additional current meter attached at 200 m and another at 400 m above the bottom current meter.

The data from these upper meters clearly defined the Gulf Stream as a strong northward flow whose meanders created speed and temperature fluctuations representing 40-70 per cent of the total variance recorded. Many of these meanders appear to have been produced by energy fluctuations occurring at 2-to 14-day intervals. These results agree remarkably well with those of other researchers.

Near-bottom flows on the two Blake Plateau moorings east of the Gulf Stream displayed prolonged southward flow events lasting up to 42 days and reaching speeds in excess of 30 cm sec^{-1}. These events did not correlate with flows at the other three sites. The generating mechanism behind these southward flows is not clear and further work will have to be performed in order to characterize the responsible mechanism.

Final Report:

Blake Plateau: Mid-depth and bottom current measurements. (GOI; 1982).

Availability:

Available from NTIS:
Final Report PB83-144519

Other Publications/Reports:

Lee, T.N. and E. Waddell. 1983. On Gulf Stream variability and meanders over the Blake Plateau at 30°N. Journal of Geophysical Research 88(C8):4617-4631.

Lee, T.N. and E. Waddell. 1982. On Gulf Stream variability at 30°N. In: Workshop on Gulf Stream Structure and Variability - Proceedings. The Office of Naval Research. Research Triangle Park, NC, April 1982. pp. 223-253.

Other Related Contracts Within This Study Program:

CT1-33/29187
CT2-62/29202

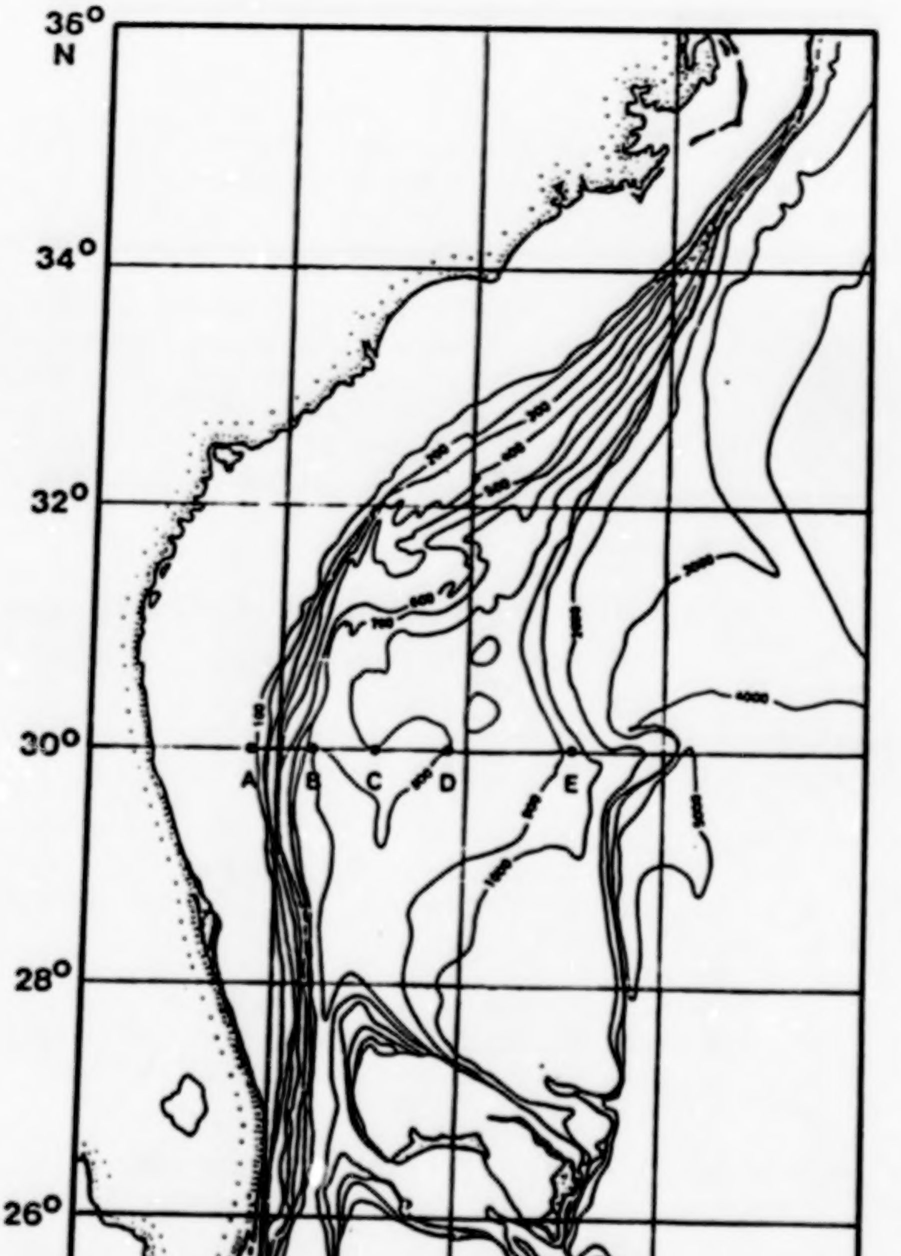

Figure 21. Location of Blake Plateau current meter mooring sites from August, 1980 to October, 1984. (Source: MMS Contract No. 14-12-0001-29176).

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BLM CONTRACT NO.: AA851-CT1-33
MMS CONTRACT NO.: 14-12-0001-29187

Title: Blake Plateau Bottom and Mid-Water Current Study, Year 2

Date: 3 March 1981 - March 1983

Cost: $383,851

Prime Contractor:
General Oceanics, Inc. (GOI)
1295 NW 163rd Street
Miami, Florida 33169

Subcontractors/Cooperating Institutions:
University of Rhode Island (URI)

Program Manager:
Chris Casagrande

Principal Participants:
Randy Watts (URI)

Contracting Officer:
Carroll Day
Jeffrey P. Petrino

COTR: Elwyn D. Wood
Murray Brown
William H. Lang

Key Words:
circulation model; circulation/current study; hydrographic, salinity, temperature data; current measurement, meters, drifters

Objectives:

1. Measure near-bottom currents along a transect at 36°N for a period of 1 year to compliment hydrographic measurements for use in circulation modeling.

2. Deploy five moorings along 36°N lat. (100-3600 m) from 1 May 1981 to 9 June 1982.

Summary:

Near bottom current/temperature measurements were made over a 1-year period at five locations from the shelf break to approximately 3,000 m water depth along 36°N. On each of the five moorings, instruments were positioned about 100 m off the bottom. This elevation was chosen to reduce the bottom boundary layer as well as any local bathymetric irregularities. All the resulting velocity/temperature data were analyzed and evaluated to create a first order description of conditions which occurred during the study.

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The instruments deployed were able to characterize mean flow and variability of the Western Boundary Under Current (WBUC). The shelf break site showed a mean southward flow, which is consistent with previous observations that in the Mid-Atlantic Bight, shelf water is transported to the south. The mid-three mooring positions were all within the WBUC with the strongest equator ward flow occurring at the middle site (Site H, 2277 m). Site I (3090 m) appears near the eastern boundary of the WBUC, and lateral shifts caused this site to experience, periodically, the associated colder water and stronger equatorward flow. The seaward mooring (J, 3700 m) is generally outside the WBUC.

At these current meter sites, several major changes correspond to lateral shifts of the Gulf Stream path. The pattern of change is consistent with a remarkably simple description: beneath the Gulf Stream a narrow region of northeastward flow seems to extend to the ocean floor. The boundary between this and the WBUC is normally between sites I and J, but shifts together with the near-surface Gulf Stream path. When the Stream is offshore of site I, the currents at that site are predominantly southward and temperatures are relatively cold. When the stream moves onshore of site I, the corresponding currents are weak and variable, or sometimes northward and temperatures are warmer.

Final Report:

Blake Plateau: Near bottom current/temperature measurements on 36°N. (GOI; 1983).

Availability:

Available from NTIS:

Final Report - PB83-205047

Other Related Contracts Within This Study Program:

CT0-35/29176

CT2-62/29202

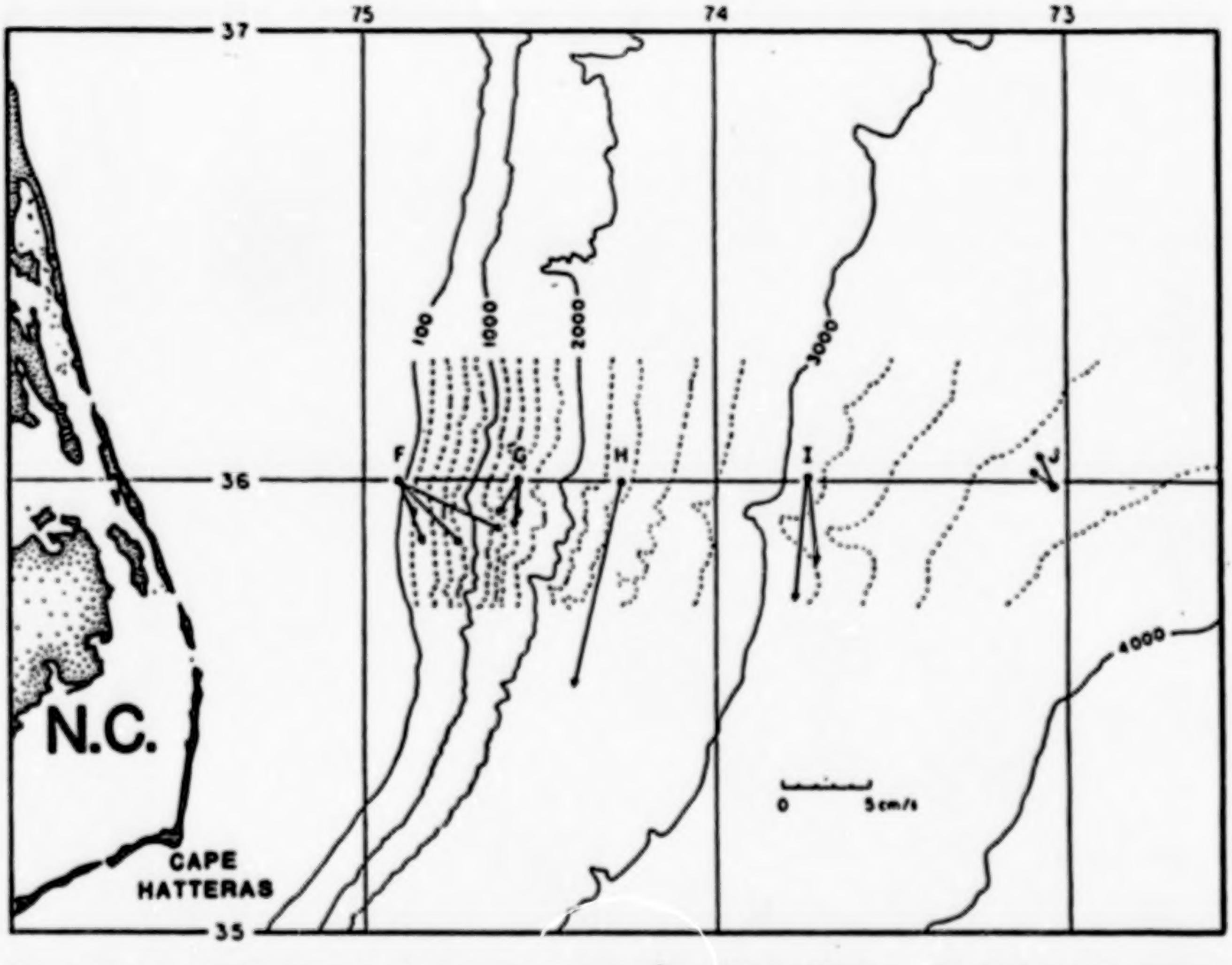

Figure 22. Mooring locations F, G, H, I, and J along 36°N. off Cape Hatteras, NC. Bathymetric contours are shown in 200m intervals. The mean current vector for each record deployment period is plotted. The speed scale is at the lower right. (Source: MMS Contract No. 14-12-0001-29187).

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BLM CONTRACT NO.: AA851-CT2-62
MMS CONTRACT NO.: 14-12-0001-29202

Title: Continued Blake Plateau Current Measurement Study, Year 3

Date: 30 September 1982 - December 1985

Cost: $3,191,971

Prime Contractor:
General Oceanics, Inc. (GOI)
1295 NW 163rd Street
Miami, Florida 33169

Subcontractors/Cooperating Institutions:
University of Miami (UM)
Skidaway Institute of Oceanography (SIO)
Applied Science Associates (ASA)

Program Manager:
Dr. Gregory Han

Principal Participants:
Larry P. Atkinson (SIO)
Otis B. Brown (UM)
Thomas N. Lee (UM)
Craig Swanson (ASA)
James Yoder

Contracting Officer:
Jeffrey P. Petrino

COTR: William H. Lang
James Lane

Key Words:
current measurements, meters, drifters; circulation/current study; transport (physical processes)

Objectives:

1. Determine the amplitude, speed, and direction of the Gulf Stream on time scales from hours to seasons.

2. Describe and quantify the current and temperature variability of the Gulf Stream in the vertical and horizontal plane.

3. Identify and describe the dominant physical processes producing the observed Gulf Stream variability and determine their spatial and temporal scales.

4. Determine Gulf Stream influences on the physical oceanography of the South Atlantic Outer Continental Shelf (OCS).

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5. Determine the importance of eddy-induced upwelling to primary productivity.

Summary:

A network of 17 current meter moorings and 63 current meters were deployed across the Gulf Stream in three transects from February 1983 through July 1985. Detailed sampling of the temperature field was carried out using aircraft deployed temperature probes (AXBT) in two deployments to define the structure of the Gulf Stream meanders and eddies. Continuous satellite observations of the surface thermal structure were used to map the eddy and meanders. Intensive shipboard measurement of the velocity, temperature, salinity and nutrient fields in and around several eddies were taken over one 20 day period in April of 1984.

The flow in the Gulf Stream is strongly influenced by the topographic feature known as the Charleston Bump located off Savannah, Georgia at 31.5° N lat.: the Stream flows directly over the bump on the average and undergoes strong bottom steering effects that produce an eastward turning of the flow and an offshore displacement of the mean axis position downstream of the bump; The mean axis of the Gulf Stream then follows the converging isobaths northward near the 800 m isobath, where it converges towards the shelf break off Onslow Bay; The offshore displacement of the Stream appears to cause the formation of a cold cyclonic (counter-clockwise rotating) gyre, the "Charleston gyre", between the displaced Gulf Stream and the continental shelf; the flow of the Gulf Stream over the bump appears to have a destabilizing effect n the current, causing amplified disturbances to develop downstream in the vicinity of Onslow Bay of weekly time scales.

Current and temperature variability over the Blake Plateau occurs primarily as low-frequency fluctuations with maximum energy levels at periods of 5, 8, 17 and 40 days. Tidal and inertial motions normally account for only a small fraction of the observed total variability.

Current and temperature fluctuations with periods of 5, 8, 17 and 40 days are identifiable (coherent) over distances of 150 km in the region west of the Gulf Stream axis, whereas in the eastern region only the 40 day period motions are coherent. The cross-stream coherent length scale is estimated at 550 km for the 5 to 17 day period motions and near 100 km for fluctuations with 40 day periods.

Gulf Stream perturbations occur as northward occur as northward propagating waves termed "meanders" and frontal eddies. The dominant wave period are the same 5, 8, 17 and 40 day periods of the most energetic fluctuations. The 5 and 8 day period waves propagate to the north at about 40 cm/s with wave lengths of 170 and 240 km, respectively. The 17 and 40 day period waves travel to the north at about 20 cm/s and wave lengths of 340 and 700 km, respectively.

The weekly period waves grow rapidly as they propagate northward of the Charleston region. Weekly period meanders and frontal eddies can form anywhere along the Gulf Stream front. They appear to amplify as

they move away from the Charleston bump and around the Charleston gyre, reaching maximum growth off Onslow Bay, where eddy diameters on the order of 100 km are observed.

The cold core of a frontal eddy is supported by upwelling of deeper Gulf Stream waters. Upwelling transports nutrients into the near surface water layers for limited utilization by primary producers.

The cyclonic circulation of frontal eddies provides a mechanism for the transport of surface materials westward and out of the Gulf Stream. Were an oil spill to occur such an eddy could propagate along the shelf break, its speed dependent on seasonal conditions thus entrapping and transporting the oil along the coast.

Remote sensing imagery of sea surface temperature indicated that cyclones and anticyclones occur along the east side of the Gulf Stream that are effective agents for the redistribution of Gulf Stream and Sargasso Sea water, causing interleaving of filaments of these water masses.

Major east-west shifts of the position of the Gulf Stream appear to occur as a long period meander that propagates to the north through the study area at a speed of about 20 cm/s, with a wave length of around 700 km and period of 40 days on the average.

A cold cyclonic circulation known as the "Charleston gyre" develops off Long Bay between the offshore displaced Gulf Stream and the continental shelf. This feature occurs approximately 60 per cent of the time. The cold center is located between the 200 and 400 m isobaths on the average. Typical dimensions of the gyre are 80 km in width and 160 km in length. The cyclonic circulation of the gyre is capable of entraining shelf water around its perimeter to be mixed into the Gulf Stream front. Onshore flow in the northern half of the gyre can provide a mechanism for shoreward transport of surface materials. Part of these materials may remain trapped within the gyre circulation and a part could by transported to the shelf from the western side of the gyre during onshore wind episodes. Surface materials transported to the shelf will then be primarily under the influence of local wind forcing.

The Gulf Stream appears to have less influence on shelf processes in the Long Bay region than occurs in the shelf at Onslow Bay to the north and off Florida to the south. Apparently this is due to the displacement of the Stream offshore at Long Bay compared to the adjacent shelf region.

Final Report:

Continuation of Blake Plateau current measurements study, semi-annual reports numbers 1 and 2. (GOI; 1984).

Blake Plateau current measurement study, final report. (GOI; 1986).

Other Related Contracts Within This Study Program:

CT0-35/29176
CT1-33/29187

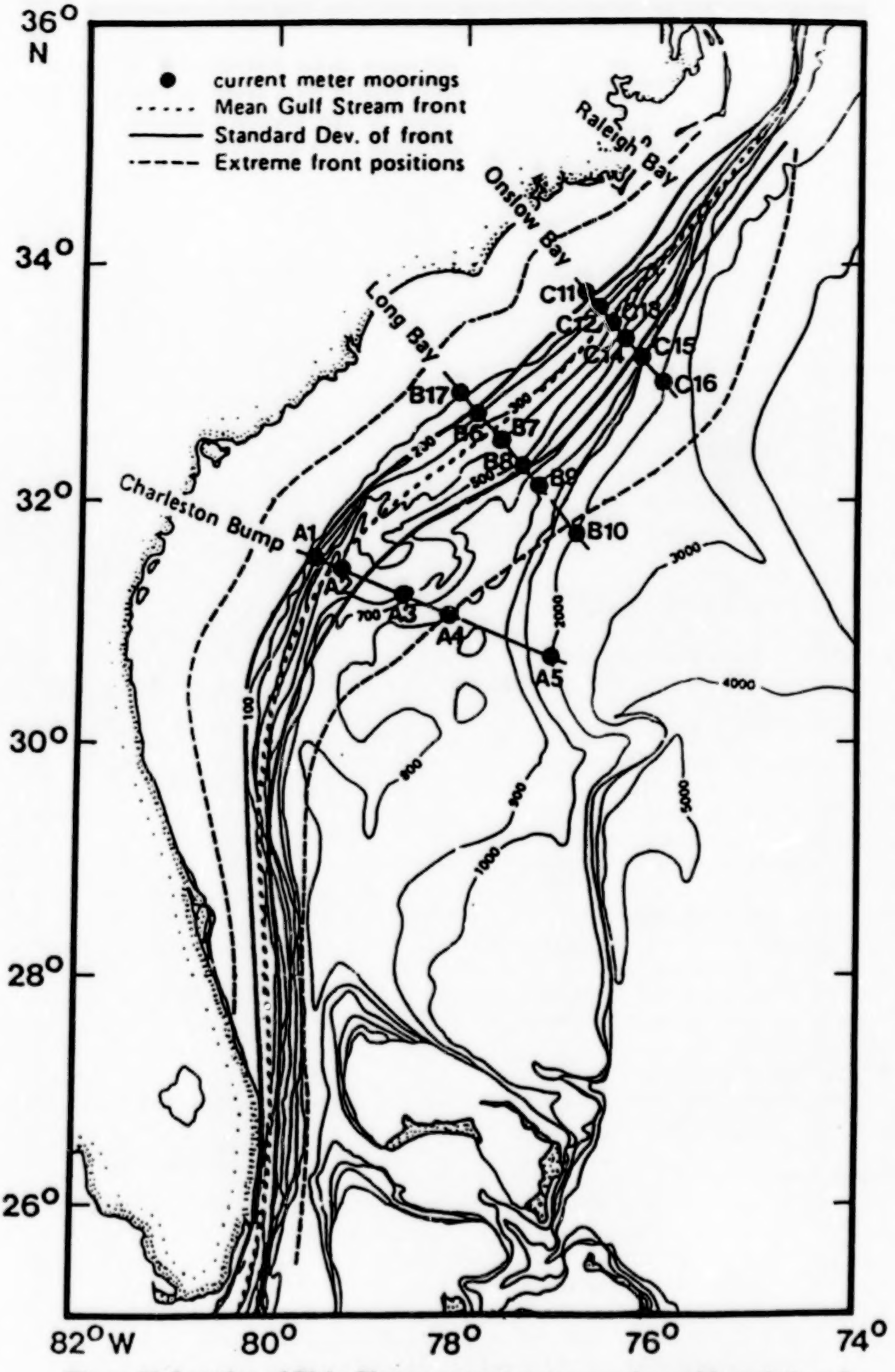

Figure 23. Location of Blake Plateau current meter moorings with statistics of satellite derived Gulf Stream cyclonic front positions. (Source: MMS Contract No. 14-12-0001-29202).

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MMS CONTRACT NO.: 14-12-0001-30082

Title: Florida Atlantic Coast Transport Study (FACTS)

Date: January 1984 - July 1985

Cost: $1,999,930

Prime Contractor:
Florida Institute of Oceanography (FIO)
830 First Street, South
St. Petersburg, Florida 33701

Subcontractors/Cooperating Institutions:
Atlantic Oceanographic and Meteorological Lab. (AMOL)
Florida A&M University (FAMU)
General Oceanics (GO)
Harbor Branch Foundation (HBF)
University of Miami (UM)
University of South Florida (USF)

Program Manager:
Murice Rinkel/Sandra Vargo

Principal Participants:
Chris Casagrande (GO)
A.D. Kirwan
Kevin Leaman (UM)
Tom Lee (UM)
George Maul
John Proni (AOML)
Friederich Schott (UM)
Ned Smith (HBF)

Contracting Officer:
Jeffrey P. Petrino

COTR: William H. Lang
James Lane

Key Words:
circulation/current study; current measurements, meters, drifters

Objectives:

1. Determine the frequencies and location of filament structures on the western edge of the Gulf Stream between 31 degrees and 27 degrees N latitude along the Atlantic coast of Florida.

2. Produce the data on the frequencies and location of filament structures in a format that is directly compatible with the circulation model of the South Atlantic prepared by Dynalysis of Princeton.

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3. Incorporate the results from this study with those of other physical oceanography studies of the Atlantic continental shelf of Florida in a synthesis of available information on the principal water masses and their circulation patterns in the region.

Summary:

The study involved the combined use of moored current meter arrays, PEGASUS current profiler, satellite tracked surface drifters, and inverted echo sounder/bottom pressure gauges (IES/PGs) to directly measure currents and particle trajectories with the Florida Current and Gulf Stream and the adjacent shelf. Satellite sea surface temperature (SST) imagery was used as a supplementary tool in the study to help interpret the data from the field instrumentation. Field sampling was conducted from March 12, 1984 through June 19, 1985.

The data gathered shows eddy events, previously detected by satellite imagery, occur at approximately weekly intervals along the western boundary of the Florida Current (south of 27°30'N) and Gulf Stream (27°30'N northward) with bursts of eddy formation from October to March. These eddies appear to form most frequently between West Palm Beach, FL and Cape Canaveral, FL. They then travel rapidly northward and westward, increasing in size and moving shoreward between 29° and 30° N. Upwelling events which could be significant for shoreward near bottom transport of drilling muds or materials from ocean mining, were detected at all current meter moorings along the 75 m isobath throughout the year.

The satellite tracked drifters provided another confirmation of surface transport by nearshore circulation features. In all, three of the thirteen drifters deployed in the FACTS area became trapped in nearshore circulation, with one actually drifting ashore. Furthermore, kinematic analysis of drifter paths indicated that the horizontal velocity vectors were small in this area and a hypothetical spill could not be dispersed by horizontal divergence or diluted by distortion of the spill. However, analysis of three out of thirteen drifters is not sufficient to assign a probability of drifter being entrapped in the nearshore circulation.

The conclusion is drawn that the nearshore small scale cyclonic circulation features along the western boundary of the Florida Current and Gulf Stream offer a possible mechanism for onshore transport of materials from OCS activities.

Reviewing the data, several recommendations can be made for continued work in the FACTS area utilizing a refined sampling design to provide further information to aid in defining the probable fate of an oil spill should one occur in this region. The FACTS program demonstrated the complementary nature of current meter measurements, PEGASUS current profiler measurements, and satellite tracked drifters. Any further study should incorporate at least these

instrumentation systems. The recommendations for further study are as follows:

1. Deployment of a longshelf current meter array along the 75 m isobath at 30' intervals from 28° N to 31° N to determine the shoreward extent and full water column effects of eddies moving into this shelf region,
2. Deployment of a cross-shelf array at 29° N extending east to at least 78°30'W for determining the role of Gulf Stream transport variability in eddy formation,
3. PEGASUS measurements at least quarterly across the section at 29° N near the current meter array to support the continuous measurements provided by the current meter array and offer backup data in the event of equipment loss or malfunction,
4. Deployment of satellite drifters from a variety of sites from 27°30'N to 28°30'N during times of bursts of eddy formation; deployment of a minimum of 3 drifters at a time to clarify probability of shoreward movement of an oil spill and tendency to disperse.

Final Report:

Physical oceanographic study of Florida's Atlantic coast region--Florida Atlantic Transport Study (FACTS). (M. Rinkel, S. Vargo, T. Lee, F. Schott, R. Zantopp, K. Leaman, N. Smith, G. Maul, and J. Proni; 1986).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS:
- Executive Summary - PB87-200994/AS
- Technical Report - PB87-201000/AS
- Appendices - PB87-201018/AS

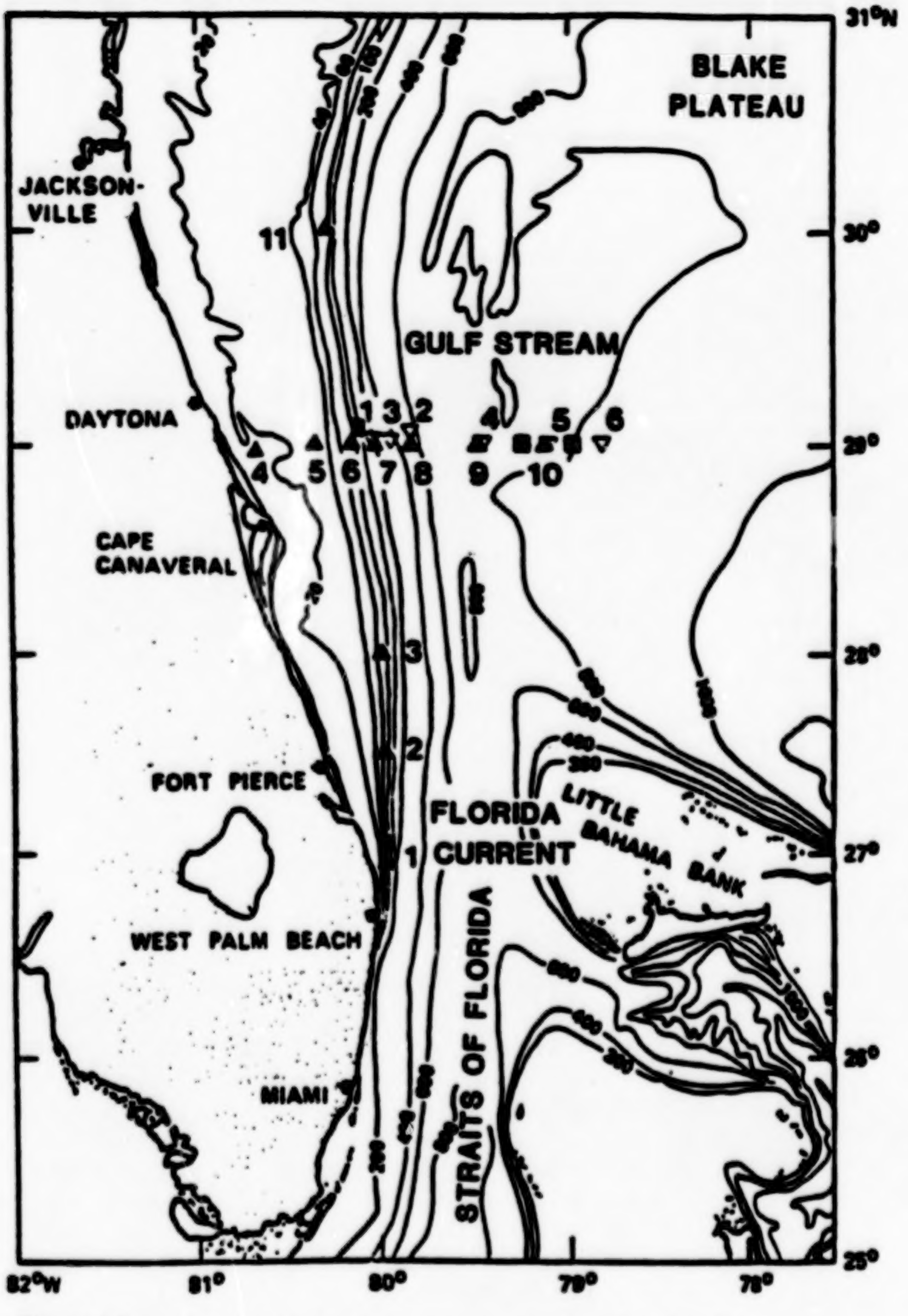

Figure 24. Locations of FACTS current meter mooring sites (▲), PEGASUS stations (△), and IES/PG sites (■). (Source: MMS Contract No. 14-12-0001-30082).

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BLM CONTRACT NO.: AA551-CT9-32
MMS CONTRACT NO.: 14-12-0001-29170

Title: Application of a Coastal Circulation Model to the South Atlantic Outer Continental Shelf

Date: 25 September 1979 - April 1982

Cost: $407,922

Prime Contractor:
Dynalysis of Princeton
20 Nassau Street
Princeton, New Jersey 08540

Program Manager:
H. James Herring

Principal Participants:
Alan F. Blumberg
Lakshmi H. Kantha
George L. Mellor

Contracting Officer:
Carroll D. Day
Linda J. DeRamus
Jeffrey Petrino

COTR: Elwyn D. Wood
William H. Lang

Key Words:
model, physical sciences; circulation model; circulation/current study; transport (physical processes)

Objectives:

1. Provide a working descriptive and predictive computer model which allows reasonably accurate predictions of such things as: surface current velocities for input into trajectory models; mid-water circulation to predict dissolved and suspended matter transport; and near-bottom currents to predict sediment transport.

2. Adapt this model to the South Atlantic Outer Continental Shelf (OCS) region, test the model with existing data, and provide quantitative values of seasonal circulation for use with the Minerals Management Service (MMS) oil spill risk analysis model.

Summary:

Circulation of the water masses in the South Atlantic Bight (SAB) has been modelled using a three-dimensional, physically comprehensive General Circulation Model (GCM) that incorporates realistic turbulent mixing and air-sea momentum, heat, and mass transfer. Open ocean

boundary conditions for this model have been deduced from a Characteristic Tracing Model (CTM 81) that uses simplified physics to drive the currents from prescribed water density and sea-surface wind stress fields. An atlas of the physical oceanographic and sea surface flux climatology of the SAB has also been prepared from a data base derived from National Climatic Center and National Oceanographic Data Center historical observation data.

The two models in consort with each other provide current distributions in the SAB at various depths in the water column. The capabilities of the models have been demonstrated by deducing the circulation distribution for typical seasons. The CTM 81 has been used to derive the prevailing 'climate' of the SAB currents, whereas the GCM has been run in both prognostic (forecast) and diagnostic (hindcast) modes. The resulting circulation agrees well with available observations.

The CTM-81 supplied open ocean boundary conditions for the GCM and diagnostically deduced transports and currents in the water column from the prescribed hydrographic and surface wind data. Results from the CTM-81 depicted well the climatological Gulf Stream and associated circulation. For purposes of providing input to U.S. Geological Survey oil spill trajectories, the climatological background currents generated by the model could be used along with 3.5 per cent rule. Sensitivity experiments revealed that a southern transect crossing the Florida Straits would be the best location to obtain supportive current flow data needed to improve model accuracy. Limitations of the CTM-81 were the inability to incorporate bottom stress terms in the potential planetary vorticity equation and the generally simplified physics involved with it.

Circulation predictions using the GCM were realistic in most cases; however, diagnostic runs produced a broader, less energetic Gulf Stream when density fields were varied. Prognostically run, the density field was allowed to evolve dynamically in accordance with model specifications depicting a more realistic Gulf Stream. Documented variations in Gulf Stream path, such as deflection by the Charleston Bump, were also shown by prognostic runs. Diagnostic simulations produced smaller deflections and generally noisier circulation patterns. Currents in the vicinity of Cape Hatteras did not indicate sufficient inflow of cold water from the Middle Atlantic Bight; this unrealistic feature was due to resolution problems across the northern boundary. Flow on the shelf was generally an Ekman response to wind forcing although some topographically induced cyclonic circulations were established. On the shelf south of Jacksonville, Florida, there was a persistent cyclonic feature exhibiting southward flow along the coast. Deep flows tended to follow planetary vorticity contours with a distinct Western Boundary Undercurrent. The Western Boundary Undercurrent entered through the northern boundary and flowed to 34°N lat. before its signal was lost.

Final Report:

South Atlantic Bight numerical model application (Dynalysis Report No. 63). (L.H. Kantha; 1980).

A diagnostic ray-tracing scheme for deducing the climatological current distribution in the South Atlantic Bight. (Dynalysis Report No. 64). (L.H. Kantha; 1980).

A diagnostic technique for deducing the climatological circulation as applied to the South Atlantic Bight. (Dynalysis Report No. 69). (L.H. Kantha, A.F. Blumberg, G.L. Mellor; 1981).

The physical oceanographic and sea surface flux climatology of the South Atlantic Bight. (Dynalysis Report No. 70). (L.H. Kantha, A.F. Blumberg, H.J. Herring, G.L. Mellor; 1981).

Circulation studies in the South Atlantic Bight with diagnostic and prognostic numerical models. (Dynalysis Report No. 71). (A.F. Blumberg, G.L. Mellor; 1981).

South Atlantic Bight numerical model application - executive summary. (Dynalysis Report No. 72). (A.F. Blumberg, H.J. Herring, L.H. Kantha, G.L. Mellor; 1981).

Availability:

Available from NTIS:

Executive Summary (Dynalysis Rep. 72) - PB83-143297
Final Report (Dynalysis Rep. 63) - On file at Minerals Management Service in Herndon, Virginia
Final Report (Dynalysis Rep. 64) - On file at Minerals Management Service in Herndon, Virginia
Final Report (Dynalysis Rep. 69) - PB83-143263
Final Report (Dynalysis Rep. 70) - PB83-143271
Final Report (Dynalysis Rep. 71) - PB83-143289

Other Publications/Reports:

Blumberg, A.F. and G.L. Mellor. 1987a. A description of a three-dimensional coastal ocean circulation model. In: Three-dimensional coastal ocean models. N. Heaps (ed.). EOS: Transactions, American Geophysical Union 5:1-16.

____________. 1983b. Diagnostic and prognostic numerical circulation studies of the South Atlantic Bight. Journal of Geophysical Research 88:4579-4592.

Kantha, L.H., G.L. Mellor, and A.F. Blumberg. 1981. Diagnostic calculations of the circulation in the middle and south bights. Ocean Modeling 37:5-11.

____________. 1982. A diagnostic calculation of the general circulation in the South Atlantic Bight. Journal of Physical Oceanography 12:805-819.

Other Related Contracts Within This Study Program:

CT2-85/29203

BLM CONTRACT NO.: **AA851-CT2-85**
MMS CONTRACT NO.: **14-12-0001-29203**

Title: South Atlantic Outer Continental Shelf Circulation Model Phase III

Date: 30 September 1982 - July 1985

Cost: $339,089

Prime Contractor:
Dynalysis of Princeton
219 Wall Street
Princeton, New Jersey 08540

Program Manager:
H. James Herring

Principal Participants:
Alan F. Blumberg
Lakshmi Kantha
George L. Mellor

Contracting Officer:
Fred M. Galinsky

Contract Specialist:
Jeffrey P. Petrino

COTR: William H. Lang
James Lane

Key Words:
circulation/current study; transport (physical processes); meteorology; model, physical

Objectives:

1. Develop an understanding of the physical and climatological factors that drive circulation along the east coast of the United States, and with that knowledge produce meaningful models that predict the movement and eventual fate of materials discharged into the ocean as a result of Outer Continental Shelf (OCS) activities.

2. Update the climatological data base used in earlier phases of the program to develop these circulation models-General Circulation Model (GCM) and Characteristic Tracing Model (CTM).

3. Improve these models through reformulations, boundary and grid modifications, and continuation of validation/evaluation efforts.

4. Expand the models to include the Florida Straits region and incorporate data buoy information from the Florida Atlantic Coast Transport Study (FACTS) program (contract no. 30082).

5. Test the GCM using a finer grid to determine its ability to predict event features of the Gulf Stream, such as meanders and eddy shedding.

Summary:

Two different, but conceptually related, models have been refined and applied to deducing the circulation along the entire east coast of the United States, including the South Atlantic Bight (SAB). The model simulations are based upon the extensive hydrographic data sets assembled from both national archives (National Oceanographic Data Center and Fleet Numerical Oceanography Center) and local sources including the observational projects supported by the Minerals Management Service. These data have been subjected to a comprehensive data analysis procedure to produce climatological distributions of the various water mass characteristics, wind stresses and heat fluxes.

The Characteristic Tracing Model (CTM 81), based on geostrophic/Ekman dynamics developed previously has been extended to include the effect of bottom stresses in the planetary potential vorticity balance. A turbulence mixing model based on second moment techniques of turbulence closure incorporated into the model takes into account the influence of the wind and bottom stresses on the currents. The enhanced model, CTM 83 is designed to provide a diagnostic means for deducing the transports and currents in the water column from the prescribed hydrographic and surface wind data. This report describes the results of the CTM 83 applied to the East Coast of the United States, with primary emphasis on the South Atlantic Bight. Both the seasonal variations and overall climatological values of the currents and transports are presented.

The East Coast region also exhibits considerable temporal variability so that the use of an already existing SAB General Circulation Model (GCM) is appropriate. After configuring the model for high resolution (approx. 5 km grid spacing), it was prudent to investigate in a simpler context some of the characteristics of eddy generation and propagation. Idealized experiments with the external mode component of the full model, run in a reduced gravity mode, demonstrate that when a Gulf Stream flow is forced around a topographic feature, intense eddies develop spontaneously; however, when the same flow traverses a region without such a feature no eddies are produced.

Final Report:

South Atlantic Bight OCS circulation model, phase III. Dynalysis Report No. 77. (Kantha, L.H., A.F. Blumberg, H.J. Herring, and G.L. Mellor, eds.; 1983).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.

Other Publications/Reports:

Blumberg, A.F. and G.L. Mellor. 1987. A description of a three-dimensional coastal ocean circulation model, In: Three-dimensional coastal ocean models. N. Heaps, (ed.). EOS: Transactions, American Geophysical Union 5:1-16.

Blumberg, A.F. and G.L. Mellor. 1983. Diagnostic and prognostic numerical circulation studies of the South Atlantic Bight. Journal of Geophysical Research 88:4579-4592.

Herring, H.J. 1985. South Atlantic OCS circulation model - program summary and progress report. Dynalysis Technical Note.

Herring, H.J., L.H. Kantha, A.F. Blumberg, and G.L. Mellor. 1983. South Atlantic Bight circulation model study. South Atlantic Regional Technical Working Group Conference, Atlanta, Georgia, March 3, 1983.

Kantha, L.H. 1983. A diagnostic calculation of the seasonal circulation along the east coast of the United States. Eleventh Annual Workshop on the Middle Atlantic Bight Physical Oceanography and Meteorology, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York, October 19-20, 1983.

Kantha, L. H. 1984. Comments on the Minerals Management Service oil spill trajectory analysis model. Dynalysis Technical Note prepared for MMS.

Kantha, L.H., G.L. Mellor, and A.F. Blumberg. 1982. A diagnostic calculation of the general circulation in the South Atlantic Bight. Journal of Physical Oceanography. 12:805-819.

Kantha, L.H., G.L. Mellor, and A.F. Blumberg. 1981. Diagnostic calculations of the circulation in the Middle and South bights. Ocean Modeling 37:5-11.

Mellor, G.L., L.H. Kantha, and H.J. Herring. 1986. On Gulf Stream frontal eddies: A numerical experiment. Ocean Modeling, 68:7-11.

Vukovich, F.M., B.W. Crissman, L.J. Pietrafesa, G.S. Janowitz, and R.H. Weisberg. 1984. Review of effects of wind and Gulf Stream events on the currents off the coast of North Carolina as it relates to oil spill risk potential.

Other Related Contracts Within This Study Program:

CT9-32/29170

South Atlantic

Biology

BLM CONTRACT NO.: **AA550-CT7-02**
MMS CONTRACT NO.: **14-12-0001-29130**

Title: South Atlantic OCS Benchmark Study, FY 1977

Date: November 1976 - September 1978

Cost: $4,055,342

Prime Contractor:
Texas Instruments, Incorporated (TI)
Dallas, Texas 75265

Program Manager:
D. Adams, M. May, III.

Principal Participants:
L. Atkinson
P. Betzer
R. George
S. Herman
B. Sen Gupta
K. Tenore
H. Windom
R. Barber
B. Coull
V. Henry
C. Oppenheimer
J. Staiger
M. Tripp

Contracting Officer:
Paul Lubetkin

COTR: Mark Grussendorf

Key Words:
characterization-ecological; benthic studies; plankton, zoo- and/or phyto-; bacteria; trace metals; hydrocarbons-chemical analyses

Objectives:

1. Determine the range of concentrations of high molecular weight hydrocarbons (HMWHC) and selected trace metals (TM) in the water, sediments, zooplankton community, and selected macro-epifaunal animals.

2. Determine natural variation in structure, abundance, distribution, and similarity of components of the benthic community.

3. Describe zooplankton communities over the continental shelf, as well as their structure, abundance, and variation.

4. Enumerate heterotrophic microorganisms; identify dominant species in surface film, near-surface water, and sediments; evaluate the oil-degrading potential of the organisms; and examine the relationship of numbers of hydrocarbon-using aerobic, heterotrophic bacteria to oil concentration in the natural environment.

5. Measure and describe concentrations of chlorophyll a, dissolved oxygen, salinity, temperature, nutrients, and particulate and total organic carbon in the water column.

Summary:
Data in support of the study objectives were collected during four seasonal oceanographic cruises in the study area, and in subsequent laboratory analyses. The results of these efforts provide a benchmark study for the South Atlantic/Georgia Bight region. Quarterly sampling clearly defined seasonal progression along the study area. Oceanic conditions are predominantly influenced by freshwater runoff and Gulf Stream intrusions onto the shelf. High nutrient and chlorophyll a values identified a persistent upwelling feature within the study area. Analyses for hydrocarbons in sediment, zooplankton, benthic fauna, and demersal fish gave little evidence of petroleum contamination. No seasonal or regional trends were apparent from trace metal analyses. Zooplankton community assessment indicated that calanoid copepod associations may be used to determine water mass mixture. The Georgia Bight shelf environment has sand bottom areas of low epifaunal biomass and hard-bottom outcrops supporting healthy epifauna and fish assemblages. Macroinfauna within the study area can be characterized as having high species diversity and low biomass due to low nutrient input and unfavorable sediment conditions. Familial meiofauna identification limited the delineation of assemblages and correlations with various physical parameters. Some foraminifera species appeared suitable as indicator species to determine changes in the state of the benthic environment. Testing of microbial hydrocarbon degradation capacity showed that degradation ability was reduced during low temperatures, indicating that fall and winter degradation of any introduced hydrocarbons would be severely reduced.

Final Report:
South Atlantic OCS Benchmark Program 1977 Report (TI; 1979).

Availability:
A review copy is available at the Minerals Management Service, Herndon, Virginia

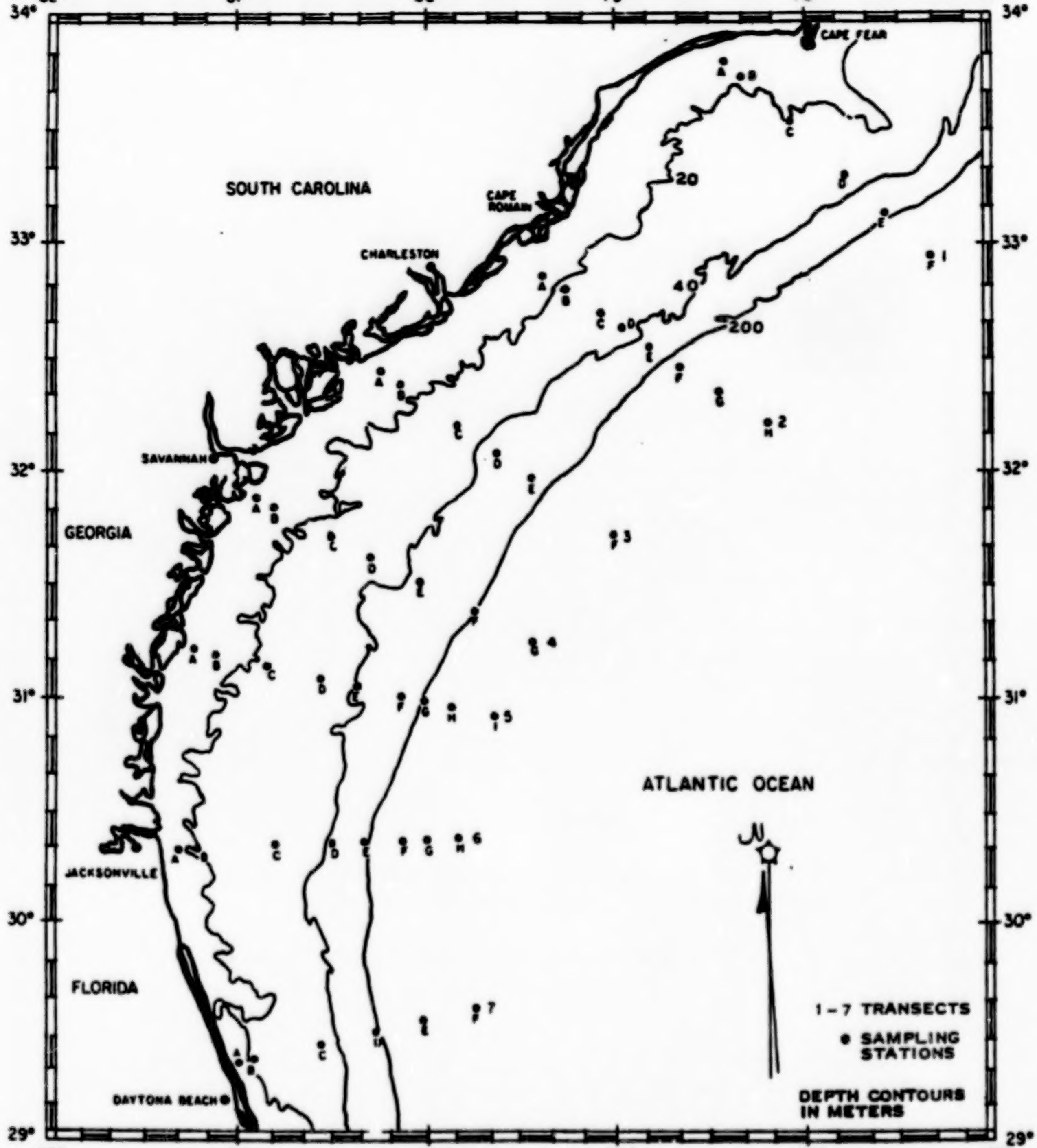

Figure 25. SABP study area and sampling stations. (Source: BLM Contract No. AA550-CT7-02).

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BLM CONTRACT NO.: AA551-CT8-25
MMS Contract NO.: 14-12-0001-30097

Title: South Atlantic Hard Bottom Study

Date: July 1978 - October 1979

Cost: $235,968

Prime Contractor:
Continental Shelf Associates, Inc. (CSA)
P.O. Box 3609
Jupiter, Florida 33458

Subcontractors/Cooperating Institutions:
Decca Survey Systems, Inc. (DSS)

Program Manager:
Robert C. Stevens, Jr.

Principal Participants:
Dennis J. Adamek
John W. Antoine (DSS)
Frederick B. Ayer (CSA)
David A. Gettleson (CSA)
Thomas E. Neurauter (DSS)
Russell Putt (CSA)

Key Words:
geology-general treatment; reefs, geology; ecological study

Objectives:
The primary objective of this study was to determine if the geologic hazards survey records to be collected in the Georgia Bight would be adequate for defining the locations of hard bottoms. The secondary objectives of this study were to:

1. Characterize the substrate comprising the hard bottom through petrographic analyses.
2. Identify the hard-bottom associated epifauna and demersal fishes.

Summary:
Four oil and gas lease blocks in the Georgia Embayment were surveyed with a precision depth recorder, side scan sonar, and subbottom profiler for the purpose of identifying and mapping areas of hard bottom. The primary objective of this study was to determine the efficacy with which standard 180 geophysical equipment and techniques could identify and map hard bottom areas. In addition, the hard bottom substrate and associated fauna were identified and described from dredge samples and color photographs.

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Inspection of geophysically mapped hard bottom areas with an underwater television camera system showed that, through the conservative interpretation of side scan sonar signatures and identification of areas of apparent outcropping of subbottom profiler, hard bottom areas can be geophysically mapped most successfully.

Petrographic analysis of 43 rock samples dredged from the hard bottom areas showed that the hard bottom was principally a recent to subrecent biostromal reef. Six lithologic types (sandstone, biomicrite, sandy biomicrite, biosparite, biolithite, and algal biolithite) were identified from the dredge samples with no significant variations in their distribution recorded between the four lease blocks.

Petrographic analyses of 43 rock samples showed that the hard bottom was principally a Recent to Subrecent biostromal reef. Six lithologic types (sandstone, biomicrite, sandy biomicrite, biosparite, biolithite, and algal biolithite) were identified from dredge samples. No significant variations in their distribution in rock samples were noted between the four blocks.

Water depth seemed to be a major factor influencing the abundance and distribution of the observed and collected species as well. Examination of videotapes and color photographs of the bottom revealed 10 distinct biological assemblages, each of which was described by its characteristic organisms. Four assemblages were noted in James Island Area Blocks 380 and 463, the most distinctive and abundant being typified by dense tube mats formed by the gregarious polychaete, Phyllochaetopterus socialis. Three assemblages were described from James Island Area Block 198 and two from Brunswick Area Block 912. The latter appeared to have the lowest abundance of epibiota of the four blocks studied. In general, abundance of epibiota appeared to be higher in areas of exposed hard bottom than in areas that were covered by a thin veneer of sand.

A total of 499 taxa (including 33 fish species) were collected in 68 dredge samples from hard-bottom areas. James Island Area Block 198 had the highest number of taxa (274), followed by James Island Area Blocks 463 (257) and 380 (214), and Brunswick Area Block 912 (71). Major groups of organisms collected were Porifera (sponges), Cnidaria (hydroids, corals, anemones, sea feathers, and sea fans), Bryozoa, Ascidiacea (sea squirts), Chlorophyta (green algae), Phaeophyta (brown algae), and Rhodophyta (red algae). Many species collected were tropical (Caribbean/West Indian) forms. Results of cluster analyses for samples within each block revealed some groupings, but these were believed to reflect sampling artifacts. Cluster analysis of samples from all four blocks indicated that James Island Area Block 198 was most biologically distinct from the others and that James Island Area Blocks 380 and 463 were the most similar to each other in composition.

Final Report:

South Atlantic Hard Bottom Study. (CSA; 1979).

Availability:
Available from NTIS:
Final Report - PB300821

Other Publications/Reports:

Gettleson, D.A., R.A. Hammer, and R.E. Putt. 1982. Geophysical and biological sea floor mapping of four oil and gas lease blocks in the South Atlantic Georgia Embayment. *In*: *Oceans '82.*

Gettleson, D.A, N.W. Phillips, and R.M. Hammer, 1985. Dense polychaete *(Phyllochaetopterus socialis)* mats on the South Carolina continental shelf. Northeast Gulf Science 7(2):167-170.

BLM CONTRACT NO.: AA851-CT9-27
MMS CONTRACT NO.: 14-12-0001-29168

Title: South Atlantic OCS Area Living Marine Resources Study, Year 1

Date: 9 September 1979 - 4 October 1982.

Cost: $739,204

Prime Contractor:
South Carolina Wildlife and Marine Resources Dept.
(SCWMRD)
P.O. Box 12559
Charleston, South Carolina 29142

Subcontractors/Cooperating Institutions:
Duke University Marine Laboratory (DUML)
Georgia Coastal Resources Division (GCRD)

Program Manager:
Project Leader - Victor G. Burrell, Jr.
Project Coordinator - Robert Van Dolah

Principal Participants:
David Ansley (GCRD)
Charles A. Barans (SCWMRD)
Billy B. Boothe (GCRD)
Dale R. Calder (SCWMRD)
Alfred G. Gash (SCWMRD)
Charles D. Harris (GCRD)
William W. Kirby-Smith (DUML)
David N. Knots (SCWMRD)
Robert K. Mahood (GCRD)
John J. Manzi (SCWMRD)
Robert Matheson (DUML)
Thomas D. Mathews (SCWMRD)
John V. Miglarese (SCWMRD)
M.B. Morehead (GCRD)
Paulette Peckol (DUML)
Jeanette H. Phillips (GCRD)
Robert J. Reimold (GCRD)
Steve Ross (DUML)
Richard Searles (DUML)
George R. Sedberry (SCWMRD)
Frank W. Stapor (SCWMRD)
B.W. Stender (SCWMDR)
Charles A. Wenner (SCWMRD)
Elizabeth L. Wenner(SCWMRD)

Contracting Officer:
Carroll D. Day
Frances L. Sullivan

COTR: Mark J. Grussendorf
Elwyn D. Wood
Robert M. Avent
Jeffrey L. Hyland

Key Words:
live (hard) bottom biology (reefs); ecological characteristics; invertebrates-general treatment of topic

Objectives:

1. Define the fish and invertebrate assemblages inhabiting nine live bottom sites in the South Atlantic Outer Continental Shelf (OCS) region.

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2. Measure physical parameters during collection.

3. Conduct remote mapping efforts (underwater television).

Summary:
The study examined nine live-bottom areas located between 30°N and 33°N latitude. Three sites were located in each of three depth zones: inner shelf waters (19-27 m), middle shelf waters (28-55 m), and outer shelf waters (55-100 m). The primary objectives were to characterize the invertebrate and nektonic communities associated with each live bottom area and evaluate factors which might influence community structure such as depth, latitude, bottom relief, season (except at North Carolina sites), and petroleum related activities.

Study results indicated the following:

Final Report:

South Atlantic OCS living marine resources study. (SCW and MRD; 1981).
Available from NTIS: PB 82-160086

Special literature analysis study: Final report on benthic communities in certain slope areas of the South Atlantic Bight. (SCW and MRD; 1985).

Availability:

Available from NTIS:
Set - PB82-160086
Executive Summary - PB82-160094
Final Report (Vol. I, South of Cape Fear) - PB82-160102
Final Report (Vol. II, North of Cape Fear) - PB82-160110
Appendices - PB82-160094

Other Publications/Reports:

Sedberry, G.R. 1987. Feeding habits of sheepshead, Archosargus probatocephalus, in offshore reef habitats of the southeastern continental shelf. Northeast Gulf Science 9:29-37.

Van Dolah, R.F. 1983. Remote assessment techniques for large benthic invertebrates. In: The visual assessment of fish populations in the southeastern United States: 1982 Workshop. Barans, C.A. and Bortone, S.A. (eds.). pp. 12-13. South Carolina Sea Grant Consortium Tech. Report No. 1, 52 p.

Other Related Contracts Within This Study Program:

CT1-18/29185
CT1-18 Mod. 5/29185

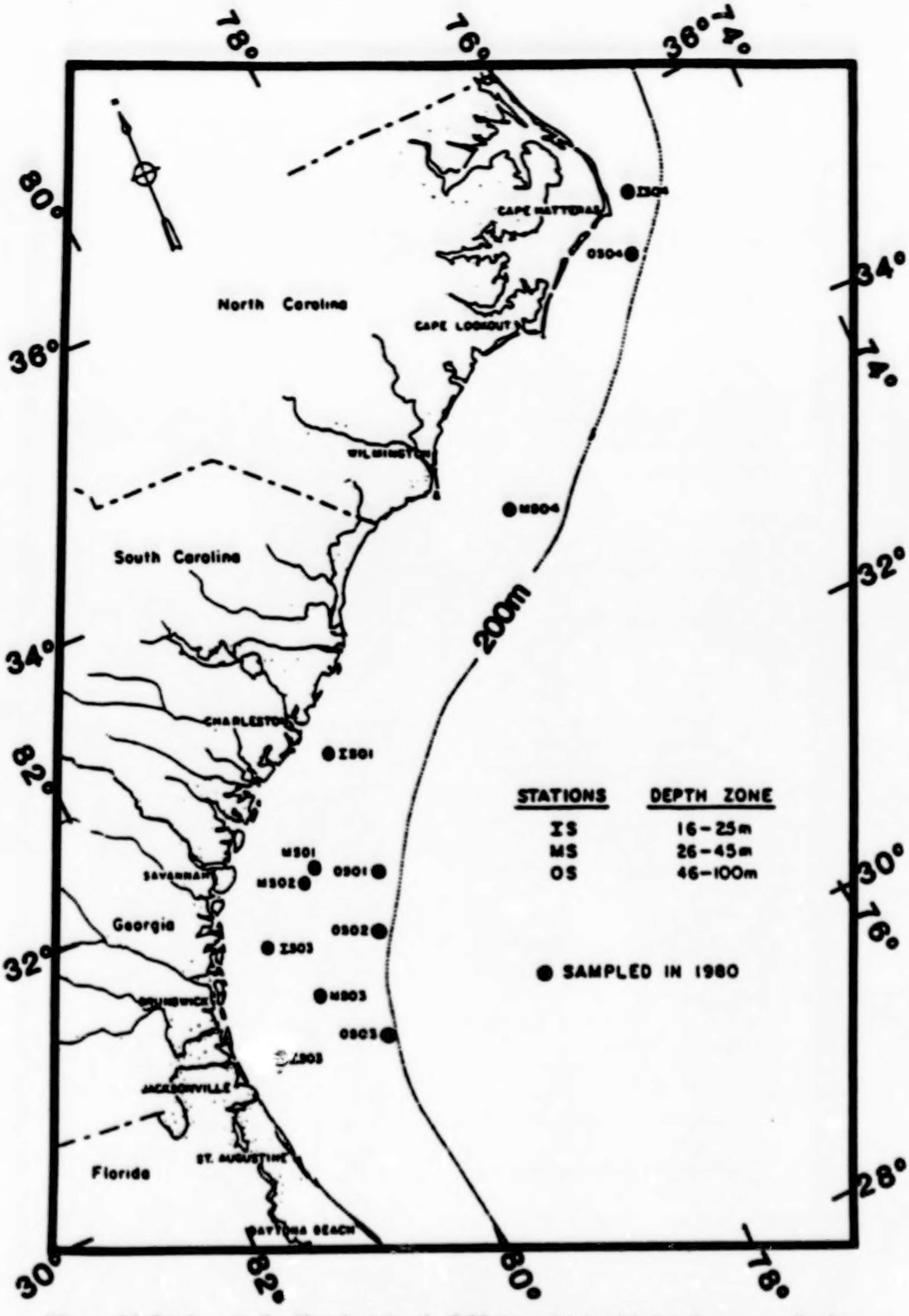

Figure 26. Study area for "South Atlantic OCS Area Living Marine Resources Study, Year 1." (Source: MMS Contract No. 14-12-0001-29168).

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BLM CONTRACT NO.: AA851-CT1-18
MMS CONTRACT NO.: 14-12-0001-29185

Title: South Atlantic OCS Area Living Marine Resources Study, Year 2

Date: 2 February 1981 - Active (see Contract No. 14-12-0001-29185 Mod. 5)

Cost: $1,420,379

Prime Contractor:
South Carolina Wildlife and Marine Resources Dept. (SCWMRD)
P.O. Box 12559
Charleston, South Carolina 29142

Subcontractors/Cooperating Institutions:
Georgia Coastal Resources Division (GCRD)
Duke University Marine Laboratory (DUML)

Program Manager:
Project Leader - Victor G. Burrell, Jr.
Project Coordinator - Robert Van Dolah

Principal Participants:
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H.L.H. Ansley
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Dale R. Calder (SCWMRD)
Alfred G. Gash (SCWMRD)
William Kirby-Smith (DUML)
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Robert F. Mahood (GCRD)
R. Matheson
Thomas D. Mathews (SCWMRD)
John V. Miglarese (SCWMRD)
N. Nicholson
Paulette Peckol (DUML)
Jeanette H. Phillips (GCRD)
Robert Reimold (GCRD)
Richard Searles (DUML)
George R. Sedberry (SCWMRD)
B.W. Stender (GCRD)
Elizabeth L. Wenner (SCWMRD)

Contracting Officer:
Frances L. Sullivan
Jeffrey P. Petrino

COTR: Rosalind Cohen
Alyce T. Fritz

Key Words:
live (hard) bottom biology (reefs); characterization-ecological; reef fish; fisheries-commercial; fisheries-sport; invertebrates-general treatment of topic

Objectives:

1. Characterize the assemblages of benthic invertebrates and demersal fishes that inhabit representative live-bottom areas in three bathymetric zones.

2. Characterize food habits of selected fish species of commercial or recreational importance.

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3. Assess bottom topography and substrate type of the live-bottom areas.

4. Formulate hypotheses on potential impacts of oil and gas related activities.

Summary:
Nine areas were sampled quarterly during 1981 to obtain more detailed seasonal data. Three of the sites were located off North Carolina, three off South Carolina, and three off Georgia. This arrangement of stations was selected to provide additional information on the geographic distribution of live-bottom fauna and flora. Bathymetric zonation of communities was evaluated by selecting three sites in each of the three bathymetric zones (16-25 m, 26-45 m, 46-100 m).

Physical characteristics of the live bottom sites were assessed through underwater-television transects, fathometer transects, and by diver observations at those sites not previously sampled during 1980. These efforts provided information on the areal extent of each site, the proportion of bottom types within each site, and the degree of rock relief. Although these techniques also provided information on the biota present, additional sampling was conducted to assess community structure both quantitatively and qualitatively. Fishes were sampled by day and night trawls, epibenthic sled, hook and line, and baited traps. Large benthic macrofauna and flora were sampled with trawls and a Cerame-Vivas dredge. Smaller invertebrates were sampled with either an airlift-suction sampler operated by divers (inner- and middle-shelf sites) or a Smith-McIntyre grab (outer-shelf sites). Bathymetric profiles of salinity, temperature, and dissolved oxygen were obtained using Niskin bottles, and water-clarity profiles were obtained using a transmissometer.

General conclusions were drawn that live-bottom areas were typified by expanses of sand-covered hard bottom and scattered outcrops and ledges of low to moderate relief (generally <2 m). Outcrops were most common at inner and outer shelf stations offshore North Carolina. Bottom coverage by epibiota averaged 75 to 100 per cent for all stations. Both tropical and warm-temperate forms of invertebrates and fishes were common. Species composition of live-bottom communities varied in relation to depth and, to a lesser extent, latitude and season. Sponges accounted for most of the attached biomass (wet weight) and for the largest number of species at all stations except on the inner and middle shelves offshore North Carolina. Enhanced abundance and diversity of fishes in comparison to results reported for soft-bottom habitats reflects in part availability of numerous food organisms and shelter associated with live-bottom habitats. Offshore oil- and gas-related activities could damage live-bottom communities by smothering or burial of epibiota, but the presence of offshore structures could have favorable effects by increasing the amount of available habitat.

Final Report:
South Atlantic OCS Area Living Marine Resources Study Year II. (SCWMRD; 1982).

Availability:
Available from NTIS:
Executive Summary - PB84-168285
Final Report (Vol. I, North Carolina) - PB84-168251
Final Report (Vol. II, South Carolina and Georgia) - PB84-168269
Appendices (Vol. III) - PB84-168277

Other Publications/Reports:
See list for Contract No. 14-12-0001-29185 Mod. 5.

Other Related Contracts Within This Study Program:
CT1-18 Mod. 5/29185
CT9-27/29168

BLM CONTRACT NO.: AA851-CT1-18 MODIFICATION 5
MMS CONTRACT NO.: 14-12-0001-29185

Title: South Atlantic OCS Area Living Marine Resources Study, Year 3

Date: 28 September 1982 - 1987

Cost: $299,931 (Estimated)

Prime Contractor:
South Carolina Wildlife and Marine Resources Dept. (SCWMRD)
P.O. Box 12559
Charleston, South Carolina 29142

Subcontractors/Cooperating Institutions:
Georgia Coastal Resources Division (GCRD)

Chartered Research Vessels:
R/V Bagby
R/V Lady Lisa
R/V Oregon

Program Manager:
Project Leader - Victor G. Burrell, Jr.
Project Coordinator - Robert Van Dolah

Principal Participants:
Priscilla Hinde (SCWMRD)
David M. Knott (SCWMRD)
H.L.H. Ansley (SCWMRD)
George R. Sedberry (SCWMRD)
James T. Stribling (SCWMRD)
Elizabeth L. Wenner (SCWMRD)

Contracting Officer:
Fred M. Galinsky
Jeffrey P. Petrino

COTR: Jeffrey L. Hyland
William H. Lang
Rosalind E. Cohen
Alyce T. Fritz

Key Words:
ecological study; live (hard) bottom biology (reefs); reef fish; invertebrates-general treatment of topic: ecological characteristics

Objectives:
Task I. Short-term and Long-term Colonization Studies

1. Analyze and compare seasonal recruitment to artificial substrates placed on both a live bottom area and on a sand bottom area distant from neighboring live bottom areas and local sources of recruitment.

2. Assess short-term succession by epibenthic organisms on artificial substrates.

3. Determine how spatial orientation (vertical vs. horizontal) of artificial substrates affects colonization and succession.

4. Assess long-term invertebrate community development patterns on artificial reef structures that are undergoing similar ecological successions but are of different ages.

5. Assess demersal fish assemblages associated with the above artificial structures.

6. Estimate the recovery period for live bottom communities following hypothetical drilling-related perturbations.

TASK II. A study of the Sediment-Depth Limitations of Dominant Live Bottom Fauna

1. Assess the distribution and density of important large live bottom taxa in relation to sediment depth.

2. Determine the sediment-depth limitations of these taxa.

3. Evaluate how changes in sediment depth related to Outer Continental Shelf (OCS) drilling activities might alter the distribution and occurrence of these live bottom fauna.

Task III. Continuation of the Study of Food Habits of Fishes Associated With Live Bottoms

1. Complete the measurement of prey selectivity indices for predator species studies during Phases I and II, based on comparisons of the diets of these species to epifaunal invertebrate species composition and abundance (as determined from suction and grab samples).

2. Determine size and age-related differences in the food habits of important fishes associated with live bottoms.

3. Analyze and compare the food habits of fishes from different bathymetric zones.

4. Determine the food habits of additional dominant and economically valuable fishes collected but not studied during the previous efforts. These additional species include Haemulon aurolineaturm, Archosargus probatocephalus, Lagondon rhomboides, Diplectrum formosum, Equetus lanceolatus, and Apogon pseudomaculatus.

5. Measure diet overlap among all fishes studied.

6. Develop a qualitative model of energy flow through the live bottom ecosystem, based on the trophic information provided by the analysis of food habits for the 13 dominant and priority live bottom fishes, the data from the analysis of benthic communities, and the information on the dependence of these fishes on the benthic community.

Summary:
This report volume describes three study tasks designed to aid in a better understanding of the possible effects of energy or mineral related activities on hard-bottom communities in the South Atlantic Bight. Task I involved a study of short-term and long-term colonization patterns by invertebrates and fishes on artificial hard substrata. Results from this task documented differences in community development related to season, surface orientation, and proximity to hard-bottom habitat. The study also indicated that recovery of hard-bottom communities from a catastrophic disturbance is likely to take several years. Task II involved a study of the distribution of sponges and corals in relation to sediment depth over hard substrata. Results from this study suggested that some sponge and coral species are very sensitive to increases in sediment cover which may result from industry-related activities. Task III was a study of food habits of hard-bottom fishes. Data obtained from this task indicated that some of the priority species examined depend on hard-bottom areas for food resources. Other fishes are less dependent on these areas for food but are only abundant in hard-bottom reef habitats. Task III results indicated that destruction of biota forming the lower trophic levels of the hard-bottom food web would seriously affect certain commercially and recreationally important fish species.

Results from this study led to the general conclusions that damage to hard-bottom communities from oil and gas operations would take years to recover and would significantly affect the feeding ecology of many reef fishes. If environmental risks were minimized, oil and gas structures placed on sand bottom areas would act as artificial reefs and promote the concentration of fishes and invertebrates in areas which previously had none. Sediment thickness is an important variable dictating the development of attached invertebrate communities in the South Atlantic Bight. Increased sediment loads over hard-bottom areas would inhibit colonization or recovery of the sponge and coral species studied.

Final Report:

South Atlantic OCS living marine resources study. (SCWMRD; 1981).

Special literature analysis study: Final report on benthic communities in certain slope areas of the South Atlantic Bight. (SCWMRD; 1985).

Availability:

A review copy is available at Minerals Management Service, Herndon, Virginia 22070.

Available from NTIS:

SCWMRD; 1981 - PB82-160086
SCWMRD; 1985 - PB87-213393/AS

Other Publication/Reports:

Sedberry, G.R. Food and feeding of the tomtate Haemulon aruolineatum (Pisces, Haemulidae) in the South Atlantic Bight. Fishery Bulletin. In review. [Describes food habits of tomtate from Year I and Year II studies].

Sedberry, G.R. and T.A. Nimmich. Food habits of some fishes associated with live bottom habitat off the South Atlantic coast of the USA. Marine Biology. In Review. [Describes fish stomach data from the Year I and Year II studies].

Sedberry, G.R., and R.F. Van Dolah. 1984. Demersal fish assemblages associated with hard bottom habitat in the South Atlantic Bight of the USA. Environmental Biology of Fishes 11(4):241-258. [Describes nektonic data obtained from the Year I study].

Van Dolah, R.F. et al. Remote assessment of sponge-coral assemblages inhabiting hard bottom areas of the South Atlantic Bight, USA. In preparation. [Describes television data for large invertebrates obtained from the Year I and Year II studies].

Wenner, E.L. Community composition and structure of decapod crustaceans from hard bottom substrates in the South Atlantic Bight. In preparation. [Describes decapod data for obtained from the Year I and Year II studies].

Wenner, E.L., D.M. Knott, R.F. Van Dolah, and V.G. Burrell, Jr. 1983. Invertebrate communities associated with live bottom habitats in the South Atlantic Bight. Estuarine, Coastal and Shelf Science 17:143-158. [Describes invertebrate data obtained during the Year I study].

Wenner, E.L., P. Hinde, D.M. Knott, and R.F. Van Dolah. 1984. A temporal and spatial study of invertebrate communities associated with hard-bottom habitats in the South Atlantic Bight. NOAA Technical Report NMFS 18:104. [Describes invertebrate data from the Year II study].

Other Related Contracts Within This Study Program:

CT1-18/29185
CT9-27/t29168

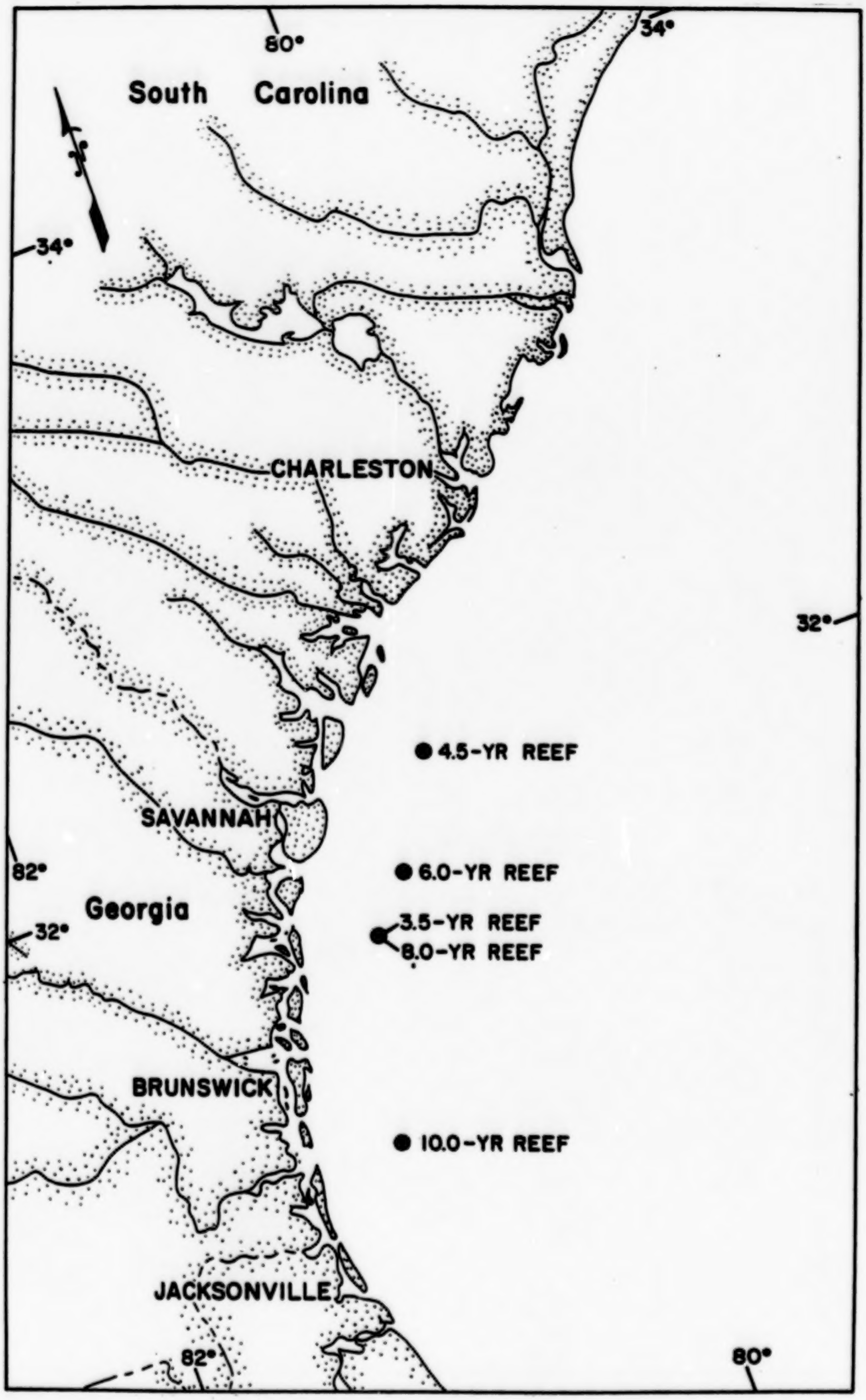

Figure 27. Location of sampling sites for long-term colonization study (Task I). (Source: MMS Contract No. 14-12-0001-29185).

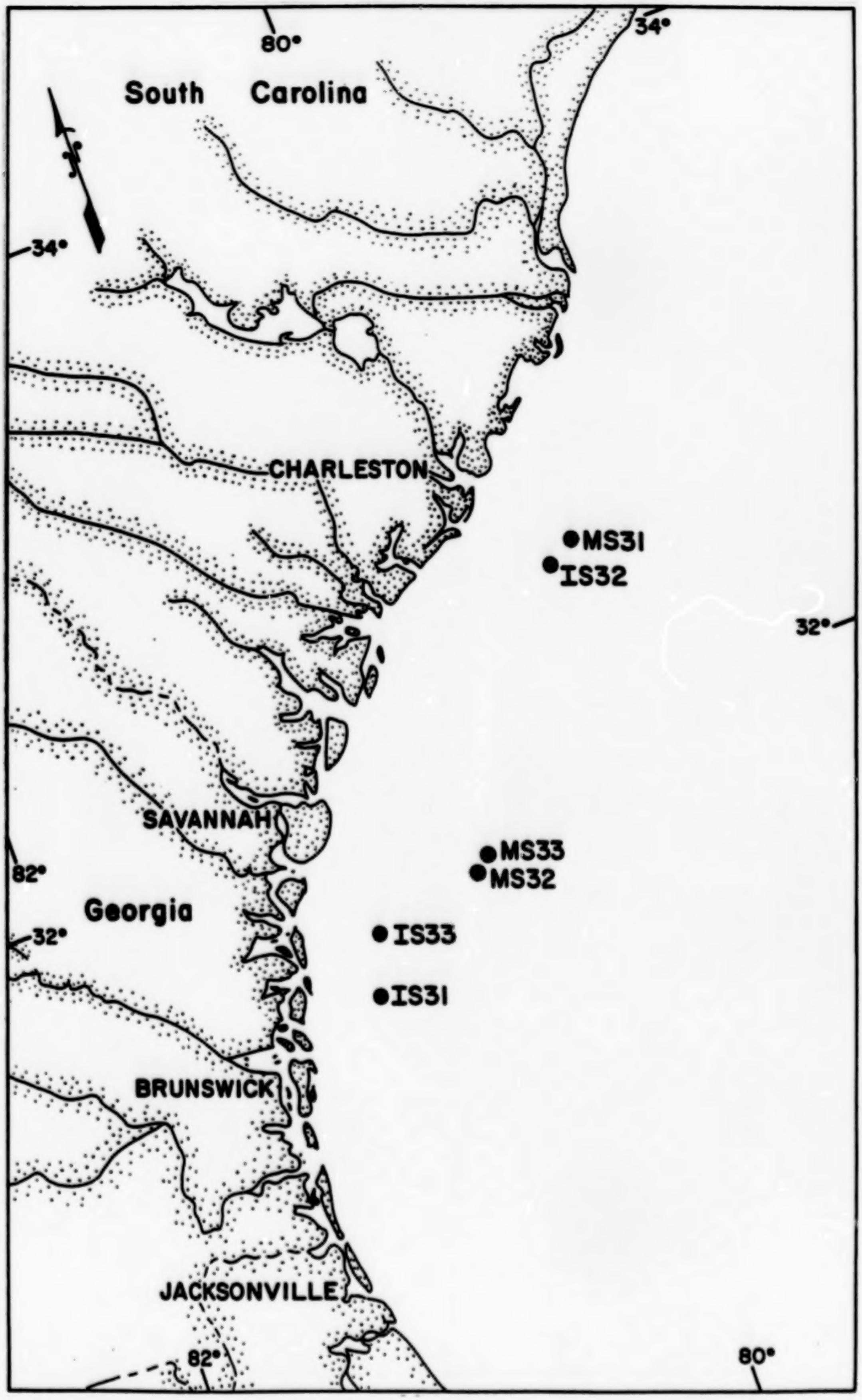

Figure 28. Location of sampling sites for sediment depth study (Task II). (Source: MMS Contract No. 14-12-0001-29185).

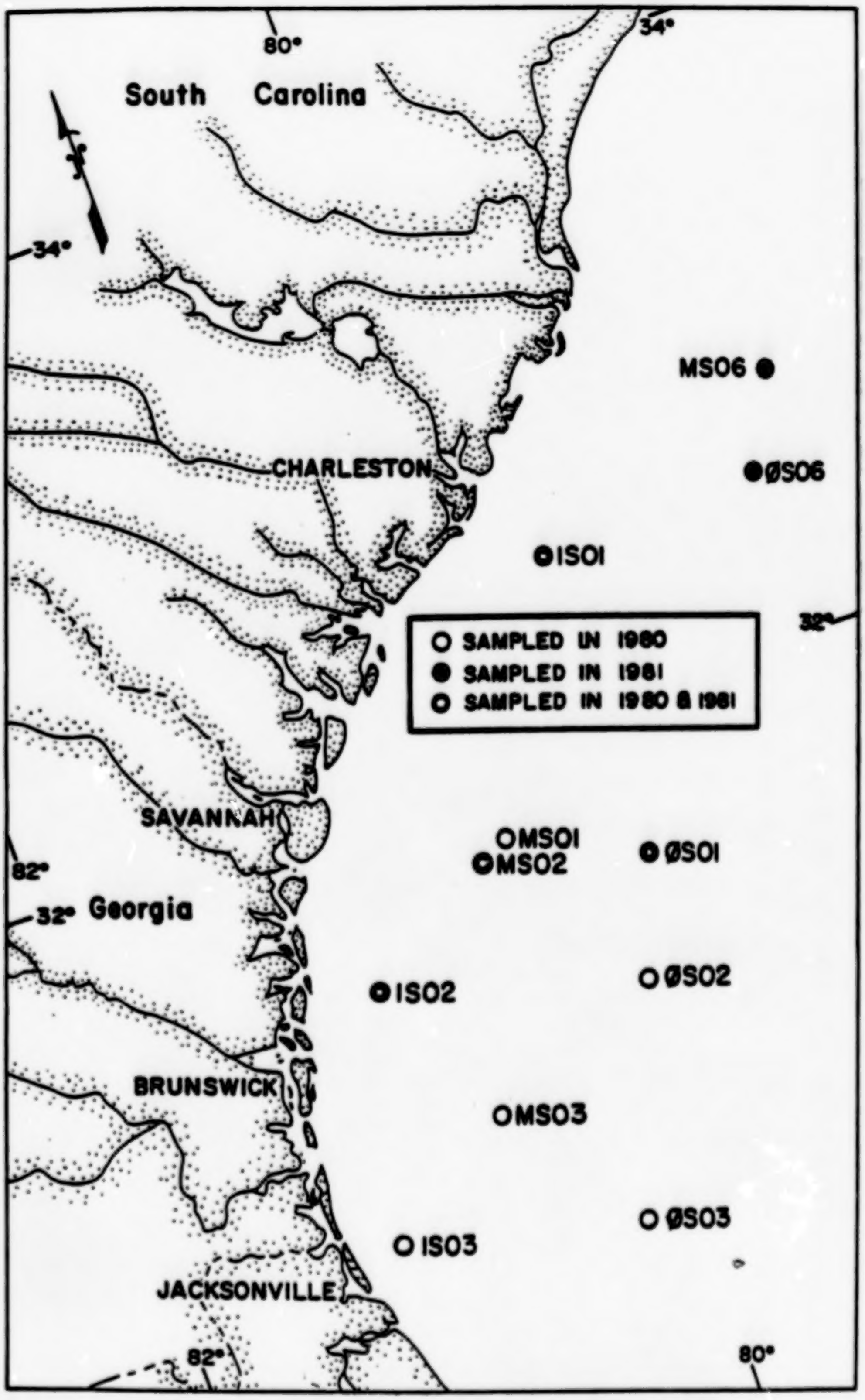

Figure 29. Location of sampling sites for habits study (Task III). (Source: MMS Contract No. 14-12-0001-29185).

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Multiregional and National Studies

Workshops and Conferences

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MMS CONTRACT NO.: **14-12-0001-30369**

Title: **Workshop to Facilitate Efforts to Develop Effective Systems for Tracking Endangered Whales**

Date: 1987

Cost: $20,097

Prime Contractor:
Marine Mammal Commission

Program Manager:
Robert Hoffman

Principal Participants:
Suzanne Montgomery

Contracting Officer:
Jeffrey Petrino
James Shilkett

COTR: Colleen Benner

Key Words:
symposium; cetacean study (general/comprehensive); marine mammal; tag, marker

Objectives:

1. Determine what if any problems must be overcome to develop a safe and effective system for long-term tracking and/or relocating large cetaceans;

2. Determine whether and if so how the identified problems might best be overcome;

3. Estimate the time, money, special equipment, and logistic support that would be required to accomplish the identified tasks.

Summary:
Available technology is adequate for at least short-term studies of the movements, activity patterns, and behavior of most cetaceans.

From experience to date, it appears that none of the tags or tagging systems currently being used cause other than superficial injuries or temporarily alter behavior. However, most radio tagged whales have no been followed or relocated over sufficiently long periods of time to conclude that tagging has no long-term effects on either behavior or survival.

There are at least two tag types that may be safe and effective for long-term, satellite-linked monitoring of the movements and other behavioral characteristics of large whales. These are the dart-type

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projectile tag, which is embedded with only the antenna protruding from the surface of the whale, and the barnacle-type tag, which is attached externally with only the attachment mechanism penetrating the skin of the whale.

A high frequency, high power output transmitter certified for use with the Service Argos detection/relay system has not been and possibly cannot be configured to fit into a projectile tag of the size range currently being used for conventional VHF radio tags. Although Service Argos certified transmitters have been configured to work in the barnacle tag, a cheap and effective system for deploying barnacle tags at distances beyond five meters has not been and possibly cannot be developed. To resolve the aforementioned uncertainties concerning the safety and effectiveness of possible systems for long-term, satellite-linked tracking of large whales, studies should be done to: 1) determine whether a Service Argos certifiable transmitter can be configured to fit into an existing or slightly larger projectile housing and, if so, whether the tag can be implanted without seriously injuring the target animals or damaging the transmitter; 2) develop and test possible promising systems for attaching barnacle-type tags to free-swimming whales at distances beyond five meters; and 3) determine how long, on the average, both projectile and barnacle tags likely will remain attached to various species of large whales and whether the tags have any long-term effects on behavior or survival.

Field trials to determine the likely retention times and possible long-term effects of selected capsule and barnacle tags on the behavior and survival of live whales would take 12-18 months to complete, would require a minimum of 45-60 days of shop and aircraft support, and would cost approximately $500,000 to $750,000, not including administrative costs. Three or more years of additional field trials might then be necessary to determine how tag configuration, materials, placement, etc., affect retention times and to adapt the prototype tags for use on different species or age/sex/reproductive classes of whales.

Final Report:

Report on the 24-26 February 1987 Workshop to Assess possible systems for tracking large cetaceans. (S. Montgomery, ed.; 1987).

Availability:

Available from NTIS: PB87-182135

Multiregional and National Studies

Environmental Inventories and Assessments

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BLM CONTRACT NO.: AA851-CT2-47
MMS CONTRACT NO.: 14-12-0001-29200

Title: An Environmental Summary of the U.S. Atlantic Continental Slope and Rise

Date: 23 August 1982 - February 1985

Cost: $220,823

Prime Contractor:
Marine Geoscience Applications (MGA)
Box 656
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)

Program Manager:
John D. Milliman

Principal Participants:
R. Gagosian
T. Joyce
D. Ross
W. Schmitz
B. Tucholke
P. Wiebe
Carolyn Winn (WHOI)
W.R. Wright

Contracting Officer:
Jeffrey P. Petrino

COTR: Eiji Imamura
William H. Lang

Key Words:
characterization-ecological; geology-general treatment; meteorology; circulation/current study; chemical analysis; fisheries-commercial

Objectives:

1. Collect and compile environmental data for continental slope and rise areas from 200 m to maximum depths within the Minerals Management Service (MMS) planning areas extending from the Canadian border south to 28°N. latitude. Data will include published and unpublished information, current research, and impending programs.

2. Synthesize and reduce this information into a usable data base, and identify gaps in environmental information.

3. Prepare a bibliographic listing of all published and unpublished reports.

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Summary:

The Atlantic Continental Slope and Rise (ACSAR) off the eastern United States is defined as lying between latitudes of 28 and 42°N, and between water depths of 200 and 4000 m. This report deals with environmental data and information in this area. It covers six general topics which together deal with the total subject. These topics include Meteorology and Air-Sea Interactions, Physical Oceanography, Geology, Marine Chemistry, Biological Oceanography, and Human Activities and Impacts. The final section of the report discusses the types of future studies which will aid in the understanding of the ACSAR environment.

Meteorology and Air-Sea Interactions

The general circulation pattern is dominated by the "Bermuda High", a high pressure system located in the subtropical gyre of the North Atlantic Ocean. About 85 per cent of all tropical cyclones, storms with sustained winds between 34 and 63 knots, occur during August, September and October. Extra-tropical storms occur mostly during the fall and winter. Precipitation over the ACSAR reaches a maximum of 1.6 m yr^{-1} over the axis of the Gulf Stream east of Cape Hatteras, dropping to less than 1 m yr^{-1} near the coast. There is a slight bias toward more rainfall in winter. Seasonal cycles of heating and cooling, evaporation and precipitation affect the temperature, salinity and related hydrography of the upper layers of the ocean.

Physical Oceanography

The character of the water overlying the Atlantic continental slope and rise changes dramatically at Cape Hatteras, where the Gulf stream diverges from the coast. Southwest of Hatteras the Stream impinges directly upon the slope. Northeast of Hatteras the Stream meanders offshore and the space between it and the shelf is occupied by slope water. Seasonal ability penetrates only to about 200 m. The ACSAR contains the strongest low frequency currents in the world, among these are the Gulf Stream and the Western Boundary Undercurrent.

Geology

The continental slope extends from the shelf slope break (60 to 200 m) to 2000 m; width varying from 10 to 50 km. The continental rise, which extends from 2000 to 5000 m and greater, is marked by a generally decreasing gradient. The "mud line" occurs at 250-300 m, below which silt and clay-size sediment predominate. On the Blake Plateau, biogenic sands and gravels predominate. The dominant sedimentary process is gravity controlled downslope movement. There are local occurrences of faulting, but only one major surface fault has subsurface expression - the outer edge of the Blake Plateau.

Chemistry

Water column distributions of dissolved nutrients depend upon both water mass and water depth. Surface concentrations are relatively depleted during warm weather months, and elevated in colder periods.

Biology

Bacteria are important and abundant, but understudied. The patchy distribution of phytoplankton in the continental slope and rise waters off the eastern U.S. are largely dictated by water mass properties and season. Zooplankton distributions are strongly affected by Gulf Stream Rings, which create a mosaic of expatriated communities interspersed with endemic communities. The size and abundance of bottom dwelling organisms decreases with increasing water depth, but average weight of fish increases below 500 m.

Human Activities and Impacts

Active commercial fishing in deep water on and over the edge of the continental shelf by U.S. fishermen includes tilefish, billfish, sharks, lobster, and red crab. Commercial fisheries for cod, haddock, silver hake, red hake, scup, sea bass, summer flounder and redfish also exist though not predominated by U.S. fishermen. Areas in and adjacent to the ACSAR area receive large quantities of wastes as a result of ocean dumping. There are two areas of special habitat which might influence development in the ACSAR area: canyon heads and canyons, and deep-water corals.

Final Report:

Environmental summary of the U.S. Atlantic continental slope and rise, 28° - 42°N. (MGA; 1984).

Availability:

Available from Minerals Management Service, Herndon, Virginia

Multiregional and National Studies

Socio-economics

BLM CONTRACT NO.: 08550-CT5-51

Title: Tourism - Related Economic Data at the County Level

Date: June 1975 - October 1975

Cost: $31,379

Prime Contractor:
U.S. Travel Data Center (USTDC)
1100 Connecticut Ave., N.W.
Washington, D.C. 20036

Key Words:
social/economic survey; economic model; recreation; oil spill effects

Objectives:
The objective of this study was to estimate the annual impact of travel activity of U.S. residents on national, state, and county economics in this country.

Summary:
The Economic Impact Model was developed to estimate the annual impact of travel activity of U.S. residents on national, state, and county economics. The disaggregated model was built upon estimates of 15 travel expenditure categories, their impact on 13 types of travel-related business at the retail level, and the business receipts, employment, and personal income tax receipts which result. Volume I describes the model including the limitations and methods for updating. Volume II is an application of the model which assesses the impacts of OCS development on "pleasure travel" in 12 Mid-Atlantic coastal counties. "Pleasure travel" was only considered because it is most apt to be altered by oil spills which may adversely affect the coastal environment.

It was clear in this study that as general business conditions decline, business travel is reduced. Moreover, common carrier travel can be expected to decline as well as traveler's switching to the automobile as an economy move. However, pleasure travel does not seem susceptible to the depressed state of the economy. Further study of the relationships between the different types of travel and economic conditions is required before definite forecasts can be made of these effects.

Final Report:
Travel Economic Impact Model; volume I -- final economic analysis methodology; volume II, final demonstration report. (USTDC; 1975).

Availability:
Available from NTIS:
Final Report - PB249365

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BLM CONTRACT NO.: **AA551-CT9-26**
MMS CONTRACT NO.: **14-12-0001-29167**

Title: Assessment of Space and Use Conflicts on the U.S. Outer Continental Shelf Between Oil and Gas Industry and Commercial and Recreational Fishermen

Date: 26 September 1979 - February 1982

Cost: $334,467

Prime Contractor:
Centaur Associates, Inc. (CAI)
Suite 465
1120 Connecticut Avenue, N.W.
Washington, DC 20036

Subcontractor:
Dames and Moore, Los Angeles (DM)

Program Manager:
Bradley S. Ingram

Principal Participants:
Fred J. Proschaska (Consulting Economist)
Martin A. Roessler (TBI)
Durbin C. Tabb (TBI)

Contracting Officer:
Jeffrey P. Petrino

COTR: Neville Chow

Key Words:
fisheries-commercial; fisheries-sport; oil and gas resources; platform, rig; social/economic survey

Objectives:
One of the major data gaps identified by previous studies and by the Minerals Management Service (MMS) in the assessment process is the degree to which oil and gas activities will conflict with commercial and recreational fishing activities. Specific objectives of this study were to:

1. Determine the probable loss in commercial and sport fishing revenues expected to be caused by withdrawal of fishing grounds to be occupied by structures such as rigs, platforms, subsea completions, pipelines, etc.

2. Determine the probable increase in commercial and sport fishing costs caused by competition for inputs, including labor, boat repair services, fuel, and harbor space.

3. Determine the degree to which the conflicts identified in (1) and (2) above can be mitigated, and cost/benefit analyses of possible mitigating measures.

Summary:
Volume I describes the types of fishing gear currently used and assesses the probable impact that oil and gas structures will have on their operation. These structures include both surface and subsurface structures such as platforms, drilling rigs, subsea completions, pipelines, etc. The geographical scope includes the following regions: North Atlantic, Mid-Atlantic, South Atlantic, Gulf of Mexico, Southern California and Northern/Central California.

The basic approach to the fishing gear descriptions was a literature review supplemented by numerous personal contacts. The assessment of potential interactions with oil and gas structures was based in part on the history of such interactions in the Gulf of Mexico, off Southern California, and in the North Sea.

Volume II specifically addresses the engineering aspects of this study. The report describes the existing and proposed offshore oil and gas technologies, the criteria and constraints used for technology selection in Outer Continental Shelf (OCS) areas, and gives specific examples for the following regions: North Atlantic, Mid-Atlantic, South Atlantic, Eastern/Central Gulf of Mexico, Southern California, and Northern/Central California. Finally, mitigating measures and their related costs are discussed and specific examples are taken from experience in the North Sea.

Volume III explores the historical interactions which have taken place between the fishing and oil and gas industries with respect to competition for labor, port space, and other areas of impacts including fuel and repair facilities, equipment, supplies, and financing. This volume includes a detailed examination of effects which have taken place in the North Sea, Southern California, Western Gulf of Mexico, and Davisville, Rhode Island. Volume IV presents results of a modeling effort to estimate the loss in catch to the commercial fishing industry due to OCS structures located on fishing grounds. The model assumes that fish move randomly in an area around an OCS structure. A Markov-type statistical process is used to model the statistical probabilities of fish moving into and out of a designated buffer zone and the probability of being caught while outside the buffer zone. The relative catch under various OCS development alternatives and with various assumed parameters is compared with the relative catch under no OCS development and analogous parameters. This produces a percentage catch loss which can be applied to the expected quantity and value of catch to estimate the expected loss.

Volume V presents the findings of site visits to 30 ports for the regions listed below and makes projections concerning the impacts of offshore oil and gas development on the fishing industry. The regions included in the analysis are the North Atlantic, Mid-

Atlantic, South Atlantic, Gulf of Mexico, Southern California and Northern/Central California. Emphasis is placed on the needs of the fishing industry as compared to the needs of the oil and gas industry for vessels, labor, space, fuel, marine repair facilities, and other inputs. The needs of the offshore oil and fishing industries have been projected over the next 30 years by region and by port.

Otter trawls, bottom dredges, and purse seines were most likely to conflict with oil structures. Submerged wellheads, pipelines, and other subsea structures were most hazardous for these gear types. Structure-related debris and activities caused more problems to fishermen than the actual oil structures. Most significant projected catch losses were related to otter trawl fisheries in the North Atlantic, Mid-Atlantic, and Eastern Gulf of Mexico regions. Fishery expansion was not expected to be significant in most areas. Competition for labor between the two industries was not appreciable; in some areas there may be a working relationship.

Final Report:

Assessment of space and use conflicts between the fishing and oil industries. (CAI; 1981).

Availability:

Available from NTIS:
- Set - PB81-215956
- Final Report (Vol. I, Fishing Gear) - PB81-215964
- Final Report (Vol. II, Engineering) - PB81-215972
- Final Report (Vol. III, Historical Interactions) - PB81-215980
- Final Report (Vol. IV, Modeling) - PB81-215998
- Final Report (Vol. V, Site Visits) - PB81-216004

BLM CONTRACT NO.: AA851-CT2-41
MMS CONTRACT NO.: 14-12-0001-29199

Title: Alternative Modes for Transporting OCS-Produced Oil and Natural Gas

Date: 5 August 1982 - 3 June 1983

Cost: $150,000

Prime Contractor:
Policy Planning & Evaluation, Inc. (PPE)
8301 Greensboro Drive, Suite 460
McLean, Virginia 22102

Subcontractors/Cooperating Institutions:
Prashant D. Agrawal
Allen R. Broyles
Robert N. DiNapoli

Program Manager:
James V. Carboni

Principal Participants:
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James V. Carboni
James D. Dickson
Robert N. DiNapoli
Jasbinder Singh

Contracting Officer:
Jeffrey P. Petrino

COTR: Neville Chow

Key Words:
oil transport; oil tankers (transport); pipelines, oil and gas; oil pipeline; transport, oil; effects-socio/economic; economic model; literature search (bibliography)

Objectives:

1. Identify possible modes of transporting oil and natural gas other than by pipeline, and the onshore and offshore facilities needed for each mode, including those needed for the offshore conversion of natural gas and the offshore storage, treatment, and loading of oil.

2. Determine the technological feasibility, regulatory framework, and environmental constraints of the facilities needed for the identified transport modes.

3. Determine the capital and operating costs of the facilities required for each transport mode, including pipeline, and the unit cost per transport system.

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Summary:
Currently the only methods used for transporting offshore oil are pipelines and tankers. Pipelines are the only proven transportation option for offshore gas. However, water depths in the Atlantic Outer Continental Shelf (OCS) extend to over 4,000 meters (13,000 feet), and these depths are beyond current pipelaying capabilities. In addition, certain areas of the Atlantic experience periods of severe weather, and it is uncertain whether existing transportation technologies can be adapted to accommodate these rough conditions.

The purposes of this study were to examine the technical developments underway to extend the capabilities of existing technologies, and to develop new approaches. For those technologies that were deemed technically feasible, a net present value analysis was conducted to test their viability. In addition to oil and gas pipelines, the study considered: 1) oil transportation by tanker; 2) natural gas conversion to liquefied natural gas; 3) natural gas conversion to methanol; 4) natural gas conversion to ammonia; and 5) electricity generation. The study was based on a detailed literature search and extensive interviews with industry representatives.

According to the analysis, pipelines have a higher net present value (NPV) for all base cases. This result is influenced to a large extent by the base case assumptions for several variables including discount rates and contingency funds. The discount rates assumed for the alternatives are, in all cases, much higher than those required for pipelines. This skewed the results against alternatives in favor of pipelines.

For purposes of this comparison, the distance to shore used for tankers in the base case was decreased to equal the distances used for oil pipelines in the base case. Then, for selected scenarios, the discount rate used for tankers in the base case was lowered to equal the mid-range value for oil pipelines. Looking at the results it is evident that even when the distance to shore (or port) is assumed equal, oil pipelines remain economically more attractive as evidenced by a higher NPV. However, when both distance to shore (or port) and the discount rate are the same for both modes, the advantage of pipelines all but disappears for large and medium size fields and, in fact, tankers are marginally more attractive for the smallest field. This shows the relative impact a change in the discount rate can have on the NPV for a particular mode. However, only oil pipelines are expected to have a discount rate this low, since they will almost assuredly be regulated by the Federal Energy Regulatory Commission.

The effect of discount rates is not as great for the gas transportation alternatives. Both conversion technologies use base-case discount rate of 13 per cent, nearly double the 7 per cent rate for gas pipelines. However, gas pipelines are significantly more attractive even when the discount rate is increased to 13 per cent. Given like discount rates, on average, gas pipelines produce

an NPV 79 per cent greater than methanol and 38 per cent greater than liquid natural gas.

Final Report:

Study of alternative modes for transporting OCS-produced oil and natural gas. (J.V. Carboni, E.M. Burrows, J.D. Dickson; 1983).

Availability:

Available from NTIS:

Final Report - PB84-140284

A review copy is available at the Minerals Management Service, Herndon, Virginia

Multiregional and National Studies

Geology and Chemistry

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BLM INTERAGENCY AGREEMENT NO.: AA551-MU9-04

Title: Studies of the Environmental Geology of the Middle and North Atlantic OCS Region (FY 1979)

Date: 9 February 1979 - February 1981

Cost: $1,284,140

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institute (WHOI)

Program Manager:
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Principal Participants:

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Key Words:
Georges Bank study; sediments (geology); hazards-geologic sediment characteristics; transport-sediments

Objectives:

The program conducted six cruises between 1 October 1978 to 30 September 1979 to collect data from bottom moored tripods/current meters, hydrographic transects, piston cores, and high resolution seismic records. Objectives of the program were to:

1. Estimate the extent and rate of sediment mobility over the seabed and monitor resultant changes in bottom morphology and texture.
2. Identify major processes causing sediment movement and assess seasonal variability.
3. Identify and study the effect of processes and mechanisms contributing to sediment instability in offshore lease areas which may lead to inception of slumping and sliding.

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4. Identify, age, and map areas of slumping and potential slump hazards in Sale 49 and 52 lease areas, and further offshore in future sale areas.

5. Determine the magnitude and potential geological hazards in Sale 40, 42, 49, 52 lease areas through historical data review and field surveys.

6. Assess the geotechnical properties of sediments in Sale 40, 42, 49, and 52 lease areas.

7. Support the activities of the physical oceanography contractor by obtaining supplemental physical measurements and helping to synthesize and interpret geological data as it pertains to physical oceanographic shelf processes.

Summary:
Circulation around Georges Bank follows a clockwise pattern with a six-month cycle time, although occasional reversals are possible. Sediment transport on the bank is considerable and under the influence of tidal and storm generated currents. Fine silts and clays are winnowed from the bank and accumulate in the "Mud Patch" region south of Martha's Vineyard; it was confirmed that this is an area of modern deposition. Continental slope sediments exhibited high shear strengths but were sensitive and would lose their strength if shocked.

Final Reports:

Environmental geologic studies in the Georges Bank area, United States northeastern Atlantic continental margin, 1978-1979. Final report submitted to the Bureau of Land Management. (O'Leary, D.W.; 1982).

Environmental geologic studies in the Mid-Atlantic Outer Continental Shelf area--results of 1978-1979 field seasons: Final report submitted to the Bureau of Land Management. (Robb, J.M.; 1982).

Summary of environmental geologic studies in the Mid-Atlantic Outer Continental Shelf area--results of 1978-1979 field seasons: Final report submitted to the Bureau of Land Management. (Robb, J.M.; 1982).

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Availability:

Available from NTIS:
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(MU8-21 and MU9-4) Final Report - PB83-147934

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Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
MU6-29CT5-42 & MU5-33
MU6-56CT6-62 & MU7-31
MU8-13MU9-04
MU8-21MU9-08/29166
MU8-24

BLM INTERAGENCY AGREEMENT NO.: AA851-MU0-18
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29175

Title: Studies of the Environmental Geology of the Middle and North Atlantic OCS Region (FY 1980)

Date: 12 June 1980 - 31 August 1983

Cost: $3,351,365

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractor/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)

Principal Participants:

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Contracting Officer:
Jeffrey P. Petrino

COTR: Eiji Imamura

Key Words:
geology-general; hazards-geologic sediment characteristics; geophysical data; sediments (geology)

Objectives:
USGS conducted a research program using the deployment of bottom moored tripods and current meters to obtain long-term measurements of pressure, current velocity, temperature, turbidity, and small-scale morphologic changes (time-lapsed photographs of the bottom); high resolution seismic records (in closely spaced lines in selected inter-canyon areas) to identify and map areas of slumping or potential slump hazards and for purposes of defining shallow sub-bottom stratigraphy and structures; and piston cores to be analyzed for geotechnical properties for integration with seismic reflection data. Finally, the USGS selectively examined and interpreted previously collected high resolution seismic records (USGS in Conservation Division). Seven cruises were planned from 1 October 1979 to 31 October 1980. Objectives were a continuation of MU9-4 tasks (1-6) in addition to new objectives which were as follows:

1. Obtain field measurements of currents, temperature, salinity, suspended sediment, and bottom processes in canyons, the continental slope, and on the adjacent shelf; document shelf-slope-canyon exchange processes,

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and characterize the currents (Lydonia-- 8 tripods, 11 current meter moorings).

2. Define the shallow sub-bottom stratigraphy and identify potential geological hazards for the nearshore environment in the Mid-Atlantic.

Final Report:

Data from this contract have been interpreted and synthesized in the final report of Contract No. IA2-26.

Other Publications/Reports:

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Other Related Contracts Within This Study Program:

MU0-16/29175
IA1-15/29183
IA1-17/29184
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31

MU6-29
MU6-56
MU8-13
MU8-21
MU8-24
MU9-04
MU9-08/29166

BLM INTERAGENCY AGREEMENT NO.: AA851-IA1-17
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29184

Title: Studies of the Environmental Geology of the Middle and North Atlantic OCS Region (FY 1981)

Date: June 1981 - September 1982

Cost: $1,252,249

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractor/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)

Principal Participants:

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Michael Bothner	James Robb
Bradford Butman	Kathryn Scanlon
John C. Hampson	David Twichell
Bonnie McGregor	

Contracting Officer:
Jeffrey P. Petrino

COTR: Eiji Imamura

Key Words:
geology, submarine canyons; sediments (geology); transport (physical processes); current measurements, meters, drifters

Objectives:
The contractor conducted nine cruises from 1 October 1980 through 31 January 1982 collect data for the following program objectives:

1. Characterize currents in Lydonia Canyon.
2. Document shelf-canyon, shelf-slope, and slope-canyon bottom and current processes by obtaining field measurements of currents, temperature, density, and suspended sediments.
3. Establish a long-term monitoring program for currents in Lydonia and Oceanographer canyons such that the seasonal variability and differences in canyon processes can be described.
4. Describe and map the morphology of the heads of Lydonia and Oceanographer canyons and their adjacent shelf and slope, and identify the processes responsible for shaping them such that pollutant transport into the canyons can be evaluated.

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5. Describe the transport mechanisms, processes, and sediment properties that influence sediment and pollutant movement into and through submarine canyons.

6. Characterize texturally sediments from the axis and walls of Lydonia Canyon and determine the distribution of heavy metals and petroleum hydrocarbons. Trends that indicate the sources of modern sediment to the canyon environment shall also be characterized.

7. Determine the rate and direction of sand wave movement and define areas of sand erosion and accumulation for Georges Bank.

8. Identify and map areas of mass sediment movement on the continental slope and in canyon areas and to relate movements to erosional processes within submarine canyon systems.

9. Estimate the extent and rate of bottom sediment movement and identify the major processes causing sediment movement with respect to the seasonal variability and dynamics of currents. The synthesis and interpretation shall emphasize the implications of the observations for movements of materials associated with pollutant transport of materials associated with offshore activity.

Final Report:

Data from this contract have been interpreted and synthesized in the final report of Contract No. IA2-26.

Other Publications/Reports:

Butman, B. and R.C. Beardsley. 1986. Long-term observations on the southern flank of Georges Bank. Part I: A description of the seasonal cycle of currents, temperature, stratification, and wind stress. Journal of Physical Oceanography 17(3):367-384.

Butman, B., M.H. Bothner, M.A. Noble, and D.C. Twichell. 1982. The Lydonia Canyon dynamics experiment: Preliminary results. EOS: Transactions, American Geophysical Union 63(18):349.

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McGregor, B.A., W.L. Stubblefield, W.B.F. Ryan, and D.C. Twichell. 1982a. Reply to Belderson and others--Comment on "Wilmington Submarine Canyon: A marine fluvial-like system." Geology 10:492.

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Olsen, H.W., B.A. McGregor, J.S. Booth, A.P. Cardinell, and T.L. Rice. 1982. Stability of near-shore sediment on the Mid-Atlantic upper continental slope. Offshore Technology Conference, 14th, Houston, Texas, May 1982, Proceedings OTC No. 4303, pp. 21-27.

Parmenter, C.M., M.H. Bothner, and B. Butman. 1983. Characteristics of resuspended sediment from Georges Bank collected with a sediment trap. Estuarine, Coastal and Shelf Science 17:521-533.

Robb, J.M. 1984a. Groundwater discharge and spring sapping on the eastern United States continental slope (abs.). Geological Society of America, Abstracts with Programs 16:636.

Robb, J.M. 1984b. Spring sapping on the lower continental slope, offshore New Jersey. Geology 12:278-282.

__________. 1985. Reply to Comment by Farre and Ryan on "Spring sapping on the lower continental slope, offshore New Jersey." Geology 13:92.

Robb, J.M. and J.C. Hampson, Jr. n.d. Detailed studies of continental slope processes and morphology. Proceedings, NOAA/NMFS National Undersea Research Symposium, Avery Point, Conn., May 1984, 15 figs. In press.

______________. 1983 Processes creating canyons and the complex submarine landscape of the continental slope off New Jersey (abs.). EOS: Transactions, American Geophysical Union 64:1051.

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________________. 1982. Surficial geological studies of the continental slope in the northern Baltimore Canyon Trough area--techniques and findings. 1982 Offshore Technology Conference Proceedings 1:39-59.

Stubblefield, W.L., B.A. McGregor, E.B. Forde, D.N. Lambert, and G.F Merrill. 1981. Sedimentological processes in Wilmington and South Wilmington canyons as indicated by observations from DSRV Alvin (abs.). Eastern Section of AAPG/SEPM. American Association of Petroleum Geologists, Bulletin 65:1671-1672.

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Twichell, D.C. 1981a. Bedform distribution and inferred sand transport on Georges Bank. U.S. Geological Survey Open File Report 81-764, 32 p.

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______________. 1981c. New insight into submarine canyon morphology from long-range sidescan sonar images (abs.). Geological Society of America, Abstracts with Programs 13(3):181.

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_______________. 1983b. Sand wave movement on Little Georges Bank. U.S. Geological Survey Open File Report 83-746, 20 p.

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Twichell, D.C. and N.G. Bailey. 1982. High-resolution seismic-reflection profiles collected over the Atlantic upper continental slope off New Jersey and Georges Bank. United States Geological Survey Open File Report 82-595, 2 p.

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Other Related Contracts Within This Study Program:

MU0-16/29175
MU0-18/29175
IA1-15/29183
IA2-26/29196
CT5-42 & MU5-33
CT6-62 & MU7-31
MU6-29
MU6-56
MU8-13
MU8-21
MU8-24
MU9-04
MU9-08/29166

BLM CONTRACT NO.: AA851-IA2-26
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29196

Title: Atlantic Geological Studies FY '82/'83

Date: 20 August 1982 - August 1983

Cost: $1,250,779

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Subcontractor/Cooperating Institutions:
University of Georgia (UG)
University of South Florida (USF)

Program Managers:
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Bradford Butman
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E.B. Forde
Patricia R. Gibson
John C. Hampson, Jr.
Vernon J. Henry (UG)
J.A. Kellman (UG)
John R. Kirby
D.N. Lambert
Charles E. McClennen
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William B.F. Ryan
William L. Stubblefield
David C. Twichell

Contracting Officer:
Jeffrey P. Petrino

COTR: Eiji Imamura

Key Words:
geology, submarine canyons; transport-sediments; sediments (geology); circulation/current study; bottom characteristics-seismic profiles

Objectives:
This Interagency Agreement (IA) is the final agreement with USGS for Atlantic geologic studies and serves to allow for completion of all tasks initiated under previous IA's. General task objectives were to:

1. Characterize currents in Lydonia Canyon.

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2. Document shelf-canyon, shelf-slope, and slope-canyon bottom and current processes by obtaining field measurements of currents, temperature, density, and suspended sediments.

3. Establish a long-term monitoring program for currents in Lydonia Canyon such that the seasonal variability can be described (FY '84 program suspended).

4. Characterize the currents and bottom transport processes on the continental slope and rise.

5. Map the morphology and shallow structures of the heads of Lydonia and Oceanographer canyons.

6. Describe the transport mechanisms, processes, and sediment properties that influence sediment and pollutant movement into and through submarine canyons and to evaluate the role of the rise as a sink for pollutants and materials transported seaward within canyon systems.

7. Characterize texturally, sediments from the axis and walls of Baltimore Canyon and determine the distribution of heavy metals and petroleum hydrocarbons.

8. Complete synthesis effort on sand wave movement for Georges Bank and the implications to Outer Continental Shelf (OCS) structures.

9. Complete synthesis on the extent and rate of bottom sediment movement with respect to seasonal variability and dynamics of currents.

10. Complete mapping of shallow subcrop geology and shallow seismic stratigraphy of the North Carolina continental shelf, slope, and rise in order to identify the processes responsible for shaping the continental margin and to reconstruct its tectonic and depositional history.

Summary:
Twenty-six cruises were conducted over the three-year period from 1980 to 1982 covering the slope and rise of the Mid-Atlantic and North Atlantic. Mid-Atlantic cruises were concentrated off New Jersey. North Atlantic cruises were mostly along Georges Bank. The cruises involved geophysical mapping, core samples for geotechnical and sediment movement analyses, deployment and recovery of instrument tripod arrays, and submersible dives side-scan sonar demonstrated that submarine canyons were morphologically similar to subaerial fluvial systems. These similarities included dendritic patterns, meander patterns, and implied relationships of maturity and gradient to channel morphology. Submersible dives confirmed these interpretations. At the mouth of Berkeley Canyon, submersible observations revealed a set of features cut into chalky sedimentary rocks of Eocene age. The furrows were 10 to 50 m apart, 4 to 13 m

deep, and 3 to 5 m wide with flat floors of fine-grained, flocky, unconsolidated sediment. The North Atlantic Lydonia and Oceanographer canyons exhibited different characteristics despite their proximity. In contrast to the fine-grained deposits in Lydonia Canyon, the floor of Oceanographer Canyon was covered by sand waves. This indicated active reworking of the bottom by strong currents. Lydonia Canyon appears to be an erosionally young feature, or erosion and deposition occur periodically within the canyon.

Sediments of the Mid-Atlantic and North Atlantic continental slope displayed considerable geotechnical variability. Undrained shear strength ranged over two orders of magnitude, plasticity ranged from high to low, sensitivity ranged from insensitive to slightly quick, and sediments may be normally consolidated to heavily over consolidated. Despite this range of conditions, surficial sediments fall into the Unified Soil Classification System "CH" category (inorganic clays of high plasticity). With the exception of canyons and canyon systems, stability analyses showed that the slope is generally stable for drained and undrained conditions. Some areas would be vulnerable if subjected to relatively minor earthquake-induced ground accelerations, excess pore pressures from gas or other sources, or slight increases in gradient from undercutting or over steepening. Near-bottom observations showed that sediment resuspension is primarily by surface waves associated with storms on Georges Bank and in the Middle Atlantic Bight. Bottom sediments were constantly reworked and scoured by semidiurnal tidal currents in some areas. Fine material was transported to the west and southwest along isobaths during major storms.

Other Publications/Reports:

Barans, C.A. and V.J. Henry, Jr. 1984. A description of the shelf edge groundfish habitat along the southeastern United States. Northeast Gulf Science 7(1):77-96.

Booth, J.S. and J.M. Robb. 1984. Stress release, joints, and instability on submarine slopes (abs.). American Association of Petroleum Geologists 68:455.

Bothner, M.H., Parmenter, C.M., and B. Butman. 1984. Resuspended sediment flux in Lydonia and Oceanographer canyons off the eastern United States (abs.). EOS: Transactions, American Geophysical Union 64(52):1051.

Butman, B. 1983. Long-term current measurements in Lydonia and Oceanographer canyons (abs.). EOS: Transactions, American Geophysical Union 64(52):1050.

Butman, B., M.H. Bothner, D.C. Twichell, and D.W. O'Leary. 1982. Present environmental studies of Georges Bank conducted by the U.S. Geological Survey. In: Workshop Proceedings, Georges Bank energy activity: An update. Kingston, RI: Center for Ocean Management Studies, University of Rhode Island, pp. 26-43.

Butman, B. and S.J. Conley. 1984. Lydonia Canyon Experiment data report, moored array, deployment I, October 1980 - April 1981. U.S. Geological Survey Open File Report 84-201, 223 p.

Folger, D.W. n.d. Geological hazards on the Atlantic continental margin of the United States. Geological Society of America Decade of North American Geology Series. In press.

Hannan, C.A., K.D. Stolzenbach, W.D. Grant, and B. Butman. 1983. Relative particle collection efficiencies of cylinders decreased with increasing trap Reynolds number in laboratory flume experiments. EOS: Transactions, American Geophysical Union 64:1061.

Klitgod, K.D. and P. Popenoe. 1983. Geophysical tectonic studies of the U.S. Atlantic coastal plain and continental margin: Extended abstract for the USGS/NRC/FEMA/NBS Workshop. *In: The 1886 Charleston earthquake and its implications for today.* W.W. Hays (ed.). U.S. Geological Survey Open File Report 83-0843, pp. 185-199.

McGregor, B.A. 1983a. Geologic processes on the U.S. Atlantic continental slope and rise in the Baltimore Canyon area (abs.). Ocean Sciences Meeting, EOS: Transactions, American Geophysical Union. 64(52):1051.

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Popenoe, P. 1984. Cenozoic depositional and structural history of the North Carolina margin from seismic stratigraphic analyses. In: Stratigraphy and depositional history of the U.S. Atlantic margin. C.W. Poag (ed.). Stroudsburg, PA: Van Nostrand Reinhold Publishing Company, pp. 125-183, 43 figs, 4 plates.

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Popenoe, P. n.d. Paleo-oceanography, paleogeography, seismic stratigraphy, and lithostratigraphy of Miocene deposition over the southwestern United States. In: World phosphate deposits. v. 3. S.R. Riggs (ed.). Cambridge, MA: Cambridge University Press. In press.

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Popenoe, P. and L.W. Ward. 1983. Description of high-resolution seismic reflection data collected in Albemarle and Croatan Sounds, North Carolina. U.S. Geological Survey Open File Report 83-513, 3 p.

Robb, J.M. 1983. Single-channel seismic-reflection data from the Mid-Atlantic upper continental rise collected by R/V Gyre (cruise 82-G-10A). U.S. Geological Survey Open File Report 83-673, 3 p.

Robb, J.M. and J.C. Hampson, Jr. 1984. Mounds of sediment along the base of the continental slope of the Mid-Atlantic United States (abs.). Geological Society of America, Abstracts with Programs 16(1):59.

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Twichell, D.C., C.B. Grimes, R.S. Jones, and K.W. Able. 1984. The role of bioerosion in shaping the outer continental shelf around Hudson Canyon, offshore eastern United States. Geological Society of America, Abstracts with Programs 16(1):68.

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Other Related Contracts Within This Study Program:

- MU0-16/29175
- MU0-18/29175
- IA1-15/29183
- IA1-17/29184
- CT5-42 & MU5-33
- CT6-62 & MU7-31
- MU9-08/29166
- MU6-29
- MU6-56
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- MU9-04

Multiregional and National Studies

Biology

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BLM CONTRACT NO.: **AA551-CT8-49**
MMS CONTRACT NO.: **14-12-0001-29164**

Title: Canyon Assessment Study in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf

Date: 28 September 1978 - 1 September 1980

Cost: $612,180

Prime Contractor:
Lamont-Doherty Geological Observatory
of Columbia University
Palisades, New York 10964

Chartered Research Vessels:
RV/Eastward

Program Manager:
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Contracting Officer:
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COTR: Philip Thomas
Jeffrey L. Hyland

Key Words:
geology, submarine canyons; corals; crabs; shrimp; benthic studies; ecological characteristics

Objectives:

1. To examine in detail the faunal assemblages from three submarine canyon systems.

2. To provide a historical survey of canyon and slope fauna from previously collected photographic data.

3. To predict possible impacts on slope and canyon faunal communities associated with resource exploration and development.

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Summary:
The abundance and distribution of the epibenthic and coral fauna of three major canyons were studied using "Cheep Tow," a towed underwater camera sled. The three canyons surveyed were Baltimore, Lydonia and Oceanographer canyons. The surveys focussed on depths between 200 to 1000 meters. Baltimore Canyon most closely resembled slope habitats. It had a high sedimentation rate and limited substrate variability in terms of extent of exposed outcrop, talus, and glacial erratics. Lydonia and Oceanographer canyons had much greater exposures of different substrate types such as outcrops of rock and consolidated clay, talus, numerous glacial erratics and areas of extensive coral debris.

The shallow-water fauna in the upper parts of the canyons was similar to that found on the slope. It was composed of a variety of species that appeared to have somewhat discrete depth ranges. In general, their distribution was patchy. The deeper water community analysis did not identify any cohesive faunal assemblages. Rather, the results indicated that the dominant fauna was not as variable, except in areas that had exposed hard substrate. The fauna was usually dominated by three species, the crab *Geryon quinquedens* and two demersal fish, *Synaphobranchus kaupi* and *rattails*. In areas of exposed hard substrate, shrimp, sponges, and coral frequently dominated. The depth ranges of the deeper-water fauna were usually quite broad. The higher concentrations of sessile filter-feeders in the northern canyons attest to the greater variety, and taxa found in canyon habitats were independently distributed, with overlapping ranges in some areas and not in others. The most obvious factor controlling the occurrence of many of the species was availability of suitable substrate. The other factors controlling their distribution are not known. Most areas within the canyons were dominated by one species rather than a group of them. This again attests to the patchiness of the faunal distributions.

Corals, both alcyonarians and scleractinians, were seen in all three canyons. The coral population of Baltimore Canyon tends to be less dense and diverse than it was in the other two canyons. The dominant coral in Baltimore Canyon was a small white sea pen that occurred on soft sediment between 100 to 300 meters depth. Both Lydonia and Oceanographer canyons had high concentrations of a variety of corals. The three dominant species in these canyons, *Eunephthya florida* in Lydonia Canyon, and *Paramuricea gandis* and *Acanthogorgia aramata* in Oceanographer Canyon, were all restricted to hard substrate. Discrete assemblages of corals were not identified. The distribution of each species appears to be controlled by slightly different habitat requirements.

Final Report:

Canyon assessment study: Epifaunal zonation and community structure in three Mid- and North Atlantic canyons. (B. Hecker, G. Blechschmidt, and P. Gibson; 1980).

Availability:
Available from NTIS:
Final Report/Appendices - PB81-15589

Other Related Contracts Within This Study Program:
CTO-59/29178

BLM CONTRACT NO.: AA851-CT0-59
MMS CONTRACT NO.: 14-12-0001-29178

Title: Study of Physical and Biological Processes of Canyons and the Continental Slope in the North and Mid-Atlantic Outer Continental Shelf

Date: August 1980 - August 1983

Cost: $4,651,777

Prime Contractor:
Lamont-Doherty Geological Observatory (LDGO)
of Columbia University
Palisades, New York 10964

Subcontractors/Cooperating Institutions:
Brookhaven National Laboratory (BNL)

Chartered Research Vessels:
DSRV *Alvin/Lulu*
RV/*Gyre*
RV/*Endeavor*
RV/*Eastward*
RV/*Johnson & Johnson-Sea-Link*
RV/*Cape Henlopen*
RV/*Oceanus*

Program Manager:
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COTR: Rosalind Cohen
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Key Words:
geology, submarine canyons; transport, physical processes; circulation/current study; zooplankton; benthic studies; characterization-ecological; oil transport; effects-ecological

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Objectives:
The purpose of this study is to examine the oceanographic processes of the Lydonia and Baltimore canyons and nearby slopes to determine what their role might be in transmitting drilling pollutants to animal life on the ocean bottom. The shelf, canyons, slopes, and the animals that inhabit them are thought to be inextricably linked in dynamic processes that are not well known at present. The objectives of this study are to:

1. Describe and characterize the currents and hydrography within submarine canyons and on the adjacent slopes, and epifauna in selected canyon and slope areas.
2. Describe the exchange of sediments and nutrients between the canyons and the adjacent shelf and the adjacent slope.
3. Determine the abiotic and biotic processes affecting the distribution and abundance of epifaunal communities.
4. Document the along-slope structure of the currents, and the canyon influence on the slope currents.
5. Identify unique and fragile communities which may be affected by oil and gas operations.
6. Identify measures for alleviating or eliminating the effects of oil and gas operations on the epifaunal communities.

Summary:
Dominant physical and biological processes operating in submarine canyon and slope areas of the eastern U.S. continental margin were examined to determine how the effects of Outer Continental Shelf (OCS) activities might be transmitted to benthic communities. Five areas were examined in detail: Baltimore Canyon and the slopes between Lindenkohl and Certeret canyons, and between Toms and Meys canyons in the Mid-Atlantic, and Lydonia Canyon and the slope between Hydrographer and Veatch canyons in the North Atlantic. Study depths ranged from 100 to 2,000 m. Physical parameters that were examined included mean current flows, suspended sediment transport, nutrient transport, nutrient concentrations, and hydrography (Mid-Atlantic only). Biological parameters included surface and near-bottom zooplankton (Mid-Atlantic only) and megafaunal populations (North and Mid-Atlantic).

The mean current flow near the surface over the slope area and Baltimore Canyon is southwestward paralleling the shoreline at speeds of 10 to 15 cm s^{-1}. Only at depths below 100 m does canyon topography influence shelf current direction. Mean currents along the canyon axis are down canyon from the head to a depth of 400 m and up canyon in the 600 to 1,000 m depth range, forming a zone of convergence between 400 and 500 m. Resuspension of particulate matter within the canyon occurred predominantly along the canyon axis

and at tidal frequencies. Sediment transport generally followed the net transport of the water.

Five major depth zones with characteristic common taxa were found between 100 and 2,000 m. Depths of transition between these zones varied slightly from area to area. Substantial overlap in taxa between adjacent zones indicated a pattern of gradual species replacement along a depth gradient. In the North Atlantic, faunal densities in Lydonia Canyon were considerably higher than at comparable depths on the shelf and slope. In the Mid-Atlantic, no consistent differences in megafaunal densities between the Baltimore Canyon and adjacent slope areas were detected.

In the Mid-Atlantic, canyon and slope trophic patterns were similar: the shelf and upper slope showed dense populations of filter feeders and/or carnivore/ scavengers; the mid-slope sparce densities of carnivore/scavengers; and the lower slope fairly dense groups of deposit feeders and filter feeders.

Results of this study showed that megafaunal assemblages in canyons may be substantially different from the surrounding slope area. Submarine canyons provide habitat for a variety of unique taxa and act as refuges for large refuge populations of sessile filter-feeding anemones, corals, and sponges. Growth rates in deepsea organisms are generally slow, and recovery of a submarine canyon megafaunal community from any major environmental impact would be slow. Canyon epifaunal assemblages should be regarded as fragile, compared to those of the shelf and slope. Taxonomic richness was highest in areas of hard substrate whether in canyons, on the shelf, or on the slope.

Final Report:
Canyon and slope processes study. (LDGO; 1983).

Availability:
Available from NTIS:
Vol. I - Executive summary - PB84-169481
Vol. II - Physical processes - PB84-169499
Vol. III - Biological processes - PB84-169507

Other Publications/Reports:

Ducklow, H.W., S.M. Hill, and W.D. Gardner. 1985. Bacterial growth and the decomposition of particulate organic carbon collected in sediment traps. Continental Shelf Research. 4:445-464.

Gardner, W.D. 1983. Suspended sediment transport in Baltimore Canyon. EOS: Transactions, American Geophysical Union 64(52):1059 (abs.).

Gardner, W.D. and K. Hunkins. 1983. Sediment dynamics in Baltimore Canyon. EOS: Transactions, American Geophysical Union 64:241 (abs.).

Hecker, B. 1982. Possible benthic fauna and slope instability relationships. In: Marine slides and other mass movements. S. Saxov and J.K. Nieuwenhuis (eds.). NATO Conference Series v. 6. New York, NY: Plenum Press. "This paper also cites the Canyon Assessment Study" CT8-49/29164).

Hecker, B. 1983. Comparison of epifaunal assemblages in two east coast submarine canyons. EOS: Transactions, American Geophysical Union 64(52):1060 (abs.).

Hunkins, K. 1983. Circulation and upwelling in Baltimore Canyon. EOS: Transactions, American Geophysical Union 64(52):1059 (abs.).

Hunkins, K. and T. Manley. 1982. Currents in Baltimore Canyon. EOS: Transactions, American Geophysical Union 63:979 (abs.).

Oakley, S., J.C. Stepien, and T.E. Whitledge. 1983. Nutrients in Baltimore Canyon and adjacent slope areas. EOS: Transactions, American Geophysical Union 64(52):1059-1060 (abs.).

Stepien, J.C. 1983. Zooplankton in Baltimore Canyon and adjacent shelf and slope areas. EOS: Transactions, American Geophysical Union 64(52):1060 (abs.)

Other Related Contracts Within This Study Program:
CT8-49/29164

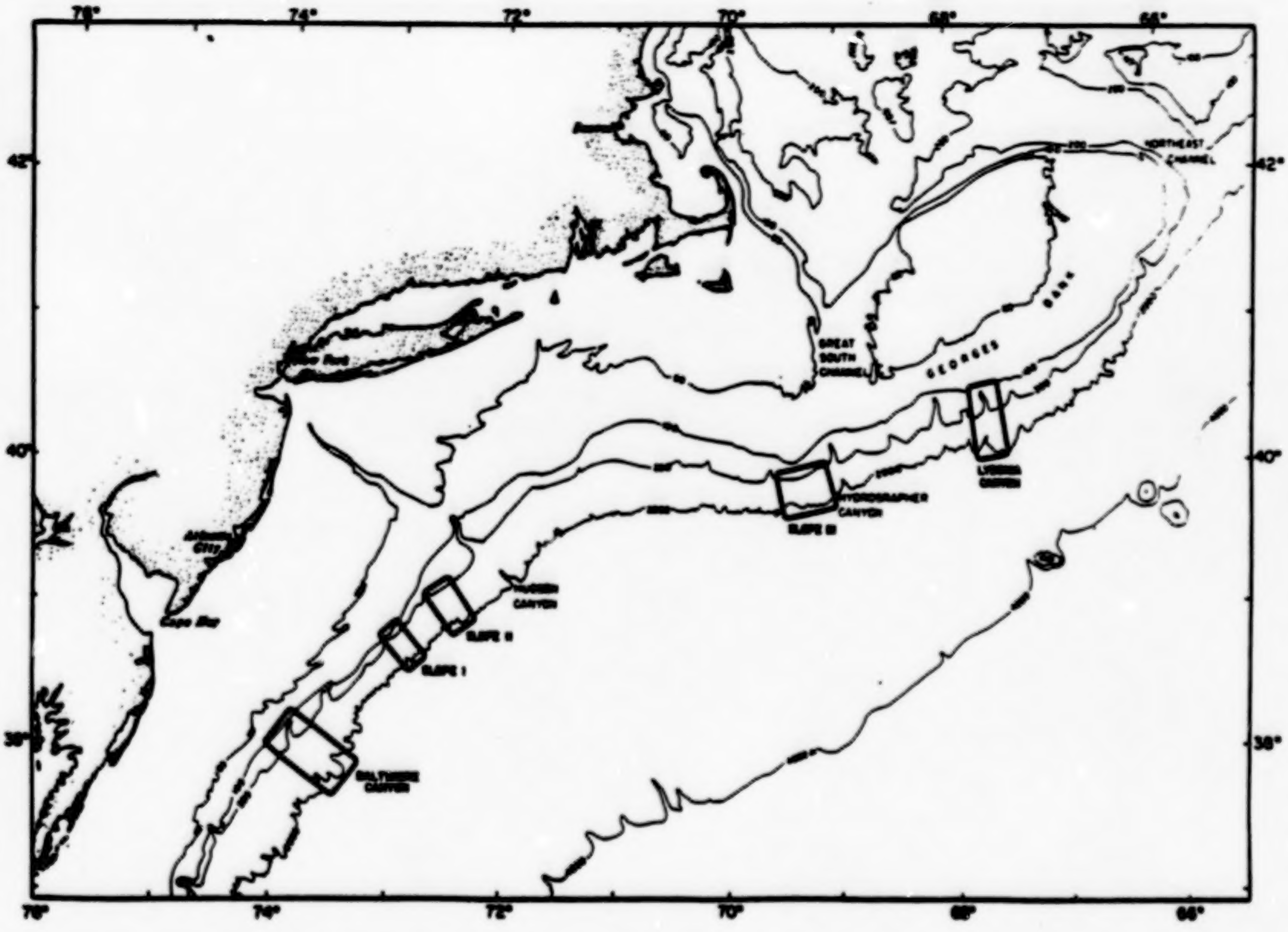

Figure 30. Map of the five study areas surveyed for benthic megafaunal assemblages. (Source: MMS Contract No. 14-12-0001-29178).

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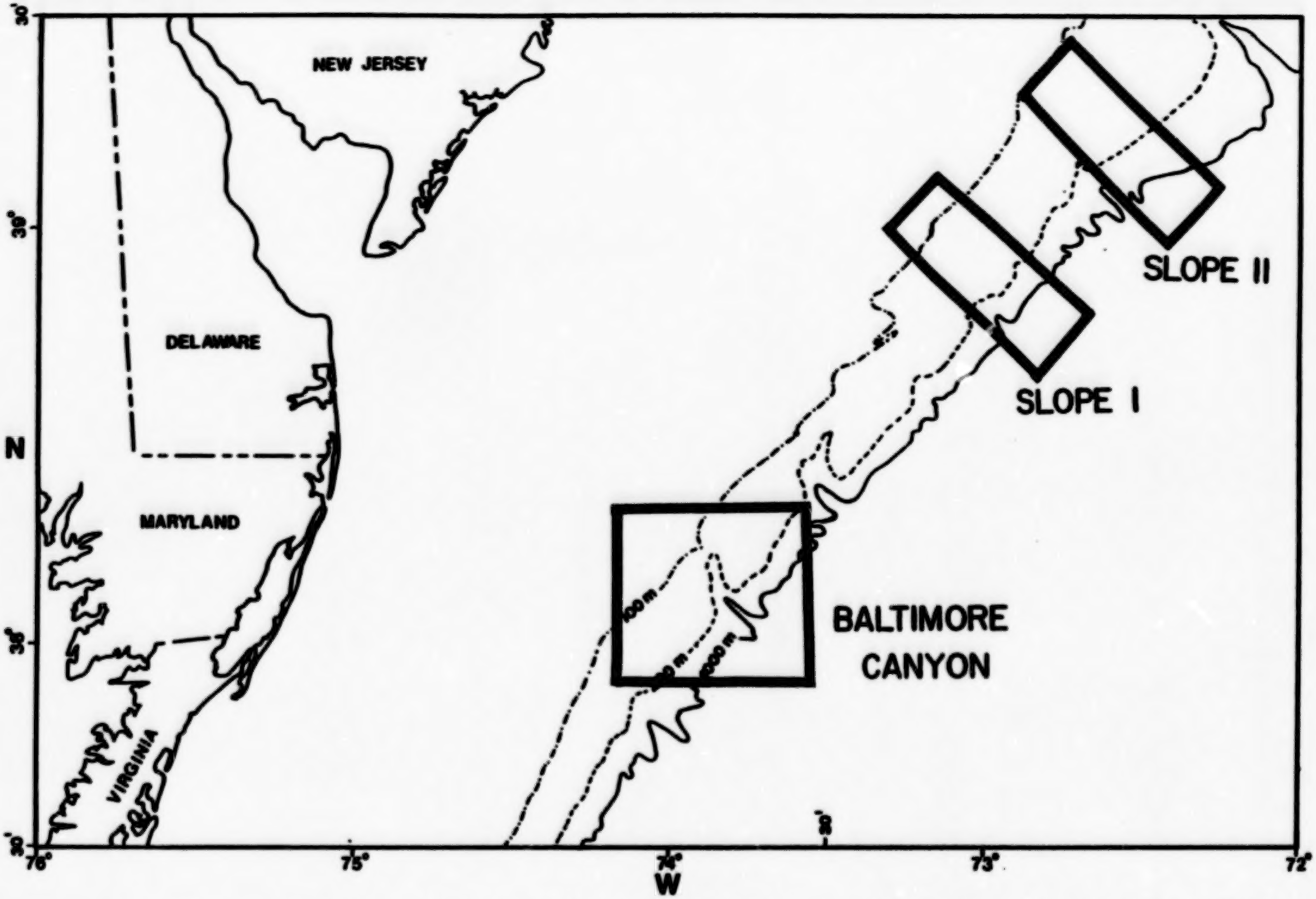

Figure 31. Location map showing areas of the physical oceanography study. (Source: MMS Contract No. 14-12-0001-29178).

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BLM CONTRACT NO.: AA551-CT9-05
MMS CONTRACT NO.: 14-12-0001-29165

Title: Study of Crude Oil Effects on Developmental Stages of the American Lobster

Date: 29 March 1979 - 9 September 1982

Cost: $119,848

Prime Contractor:
Woods Hole Oceanographic Institution (WHOI)
Woods Hole, Massachusetts 02543

Program Manager:
Judy Capuzzo

Principal Participants:
John H. Ryther

Contracting Officer:
Fred M. Galinsky

COTR: Eiji Imamura
William H. Lang

Key Words:
lobsters; effects of oil, hydrocarbons; larval stages (life history); feeding

Objectives:
This work is a continuation of an effort begun by the Westinghouse Electric Corporation under Contract No. AA550-CT7-24 and shall not repeat work completed by Westinghouse. Basic objectives were to:

1. Study the effects of exposure of the developmental stages of the American lobster to South Louisiana crude oil.
2. Test the effects of ingestion of oil contaminated food (*Artemia salinia*) on larval growth and development. Parameters investigated were: feeding rates and behavior, growth rates, molt durations, respiration rates, ammonia excretion rates, and O:N ratio.
3. Determine sublethal effects on juvenile lobsters exposed to contaminated sediments.
4. Study body burden and depuration of oil in larval lobsters.
5. Complete histological studies initiated by Westinghouse.
6. Study lipid utilization and storage in oil-exposed larvae.

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Summary:

The physiological effects of South Louisiana crude oil on larvae and juveniles of the American lobster, Homarus americanus, have been investigated in continuous flow bioassay systems. Three sets of experiments were conducted to address study objectives. One focused on physiological effects on all larval stages of chronic exposure to crude oil in seawater. A second set examined effects of exposure to oil in seawater and sediments on juvenile (post-larval) lobsters.

Disruptions in the energetics of larval development were observed upon exposure to oil-seawater mixtures and to an oil-contaminated food source. Larval lobsters fed a contaminated food source showed earlier signs of stress than did those exposed to an oil-seawater mixture, although later larval stages of those exposed to oil-contaminated food showed some restoration of normal energetic patterns during exposure. In larval stages, hydrocarbon turnover was rapid and little accumulation was noted; larvae and early juveniles, when transferred to clean seawater, gradually resumed normal energetic patterns. Juvenile lobsters were less sensitive to oil-seawater mixtures than were larvae. However, juveniles were sensitive to oil-contaminated sediments and appeared to have longer retention times of hydrocarbons.

Postlarval lobsters are less sensitive to crude oil-seawater mixtures than the larval stages and no disruption in energetics has been observed. Reductions in respiratory activity and bioaccumulation of both aliphatic and aromatic compounds, however, have been observed in postlarval lobsters exposed to oil contaminated sediments. This suggests that postlarval lobsters have longer retention times and lower turnover rates of petroleum hydrocarbons than the larval stages, and persistence of petroleum hydrocarbons in sediments may present a chronic contamination problem to benthic stages of the American lobster.

Final Report:

Crude oil effects on developmental stages of the American lobster, 92 p. + Appendix (Westinghouse Ocean Research Laboratory, 1978. Crude oil effects to developmental stages of American lobsters. Final Summarization, 27 p.). (J.M. Capuzzo; 1982).

Availability:

Available from NTIS:
Final Report - PB82-117656

Other Publications/Reports:

Capuzzo, J.M., and B.A. Lancaster, 1981. Physiological effects of south Louisiana crude oil on larvae of the American lobster (Homarus americanus). In: Biological monitoring of marine pollutants. New York, NY: Academic Press. pp. 405-423.

MMS CONTRACT NO.: 14-12-0001-30336

Title: Synthesis of Knowledge of the Potential Outer Continental Shelf Impacts from Oil and Gas Activities on Fisheries

Date: September 1986 - September 1989

Cost: $371,802

Prime Contractor:
Technical Resources, Inc. (TRI)
3202 Monroe Street
Rockville, Maryland 20852

Program Manager:
Mr. Drew Zacherle

Principal Participants:
Eulalie Sullivan
Lucinda Tear

Contracting Officer:
Carolyn Golden

COTR: Robert Miller

Key Words:
fisheries study; fisheries-commercial; fisheries-shellfish; abundance-population; bibliography, annotated or literature search; effects of oil, hydrocarbons; literature search, bibliography

Objectives:

1. Compile and assess information on the distribution and abundance of designated major fish and shellfish species in each U.S. Outer Continental Shelf region.
2. Evaluate the state of knowledge of potential impacts of oil and gas activities on fish and shellfish fishery resources with an assessment of the transferability of both site- and species-specific research to other geographical areas and species.
3. Identify gaps in existing knowledge for the designated major species.

Summary:

For each species, this report discusses its apparent distribution and abundance in U.S. waters, apparent historical trends in its distribution and abundance, and gaps in existing knowledge. The distribution and abundance discussions include information on the geographical range of the species along U.S. coasts; the maximum and minimum distance offshore (or depth) where the species is found; major known spawning, and nursery areas; and when appropriate, major

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migration routes. Each section also presents the maps portraying the known distribution of the species. The species distribution maps exhibit those geographical areas in which the species is as least seasonally common. The sections addressing the gaps in existing knowledge focus on those aspects of species distribution and relative abundance that have been identified in the literature as being particularly lacking.

Appendix I includes descriptions of databases that contain information concerning the distribution and abundance of the report's target species and an annotated bibliography of the literature on target species distribution and abundance. This appendix includes nearly 2,800 abstracts of distribution and abundance studies and over 350 descriptions of databases related to the target species; distribution and abundance. Appendix II is an annotated bibliography of literature on potential OCS oil and gas activity impacts on finfish and shellfish species and on fisheries. The second appendix includes over 1,750 abstracts. Both appendices include indexes to assist the reviewer in locating studies on databases related to the topic of interest.

The annotated bibliographies of fishery distribution and OCS oil and gas activity impact studies include abstracts of the peer-reviewed literature as well as grey literature. The studies presented in the bibliographies are listed alphabetically by the primary author's last name and include the following information: 1) author(s); 2) the year and study was published; 3) the publication information of the study; and 4) a brief description of the purpose and results of the study.

The description of databases containing information relevant to the distribution and abundance of the target species are listed in alphabetical order by the name of the database. In those few cases where the study's principal investigator did not assign a specific named to the database, the database is identified by the author's name or by the name of the institution where it is located. For each database, the name and address of a database contact is given.

Final Report:

Synthesis of knowledge of the potential impacts of OCS oil and gas activities on fisheries. (TRI; 1989).

Vol. I. Distribution and relative abundance of target species

Vol. II. Executive Summary

Appendix I. Annotated bibliography and database descriptions for target species distribution and abundance studies. Sections I. and II.

Appendix II. Annotated bibliography for OCS oil and gas impact studies.

Multiregional and National Studies

Drill Site Monitoring

MMS CONTRACT NO. 14-12-0001-30064

Title: Study of Biological Processes on the U.S. Atlantic Continental Slope and Rise--Part A: Studies of Biological Processes on the U.S. North and Mid-Atlantic Slope and Rise--Part B: Studies of Biological Processes on the U.S. South Atlantic Slope and Rise

Date:
30 September 1983 - Still Active
30 September 1983 - Still Active

Cost:
$ 3,007,520 (Paid out for Part A)
803,181 (Paid out for Part B)
$ 3,810,701 (Total Paid out)

$ 4,720,723 (Total Obligated)
$8,531,424 Total

Prime Contractor:
Battelle New England Marine Research Laboratory (BNEMRL)
397 Washington Street
Duxbury, Massachusetts 02332

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution (WHOI)
Lamont-Doherty Geological Observatory (LDGO)

Chartered Research Vessels:

R/V *Gyre*	(Part A)
R/V *Oceanus*	(Part A)
R/V *Cape Hatteras*	(Part A)
R/V *Columbus Iselin*	(Part B)

Program Manager:

Nancy Maciolek-Blake	(Part A)
James Blake	(Part B)

Principal Participants:

Part A:	Fred Grassle (WHOI) Paul Boehm (BNEMRL) Barbara Hecker (LDGO) Nancy Maciolek-Blake (BNEMRL)
Part B:	James Blake (BNEMRL) Paul Boehm (BNEMRL) Fred Grassle (WHOI) Barbara Hecker (LDGO)

Contracting Officer:
Jeffrey P. Petrino
Jim Shilkett

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COTR: Jeffrey L. Hyland
Rosalind E. Cohen
Alyce T. Fritz
Robert Miller

Key Words:
ecological processes; ecological study; benthic studies; geology general treatment; invertebrates- general treatment of topic; drill site monitoring

Objectives:

1. Characterize pre-drilling biological, geological, and chemical properties of benthic environments at a limited number of stations in the general vicinity of an exploratory drilling rig in each of the three study areas - North Atlantic (NA), South Atlantic (SA), Mid-Atlantic (MA).

2. Monitor potential changes in these properties with time, and determine whether the changes are caused by drilling-related activities or whether they are the result of other phenomena including natural temporal or spatial variation.

3. Determine the distribution and fate of discharged drilling-related materials that have accumulated above background levels.

4. Estimate recovery rates of deep-sea benthic communities potentially impacted by drilling-related activities.

North and South (Phase II) Atlantic:

1. Characterize biological, geological, and chemical properties of benthic environments at a limited number of stations within areas of potential oil and gas development on the Atlantic Continental Slope and Rise.

2. Monitor potential changes in those properties with time to determine the extent of natural temporal and spatial variation.

3. Estimate recovery rates of deep-sea communities potentially affected by drilling-related activities (North only).

Note: The South Atlantic program (Part B) also includes a benthic baseline characterization study (Phase 1 of SA program) which focusses on the following objectives: 1) to characterize biological and surficial geological properties of benthic environments at a limited number of slope/rise sites within areas of potential oil and gas drilling activities in the SA; 2) to provide information on seasonal and spatial variation of communities observed at slope and rise locations the SA; and 3) to provide a limited regional data base

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to facilitate evaluation of Phase 2 (SA rig-monitoring study) results.

Summary:

North Atlantic

Continental slope and rise fauna of the U.S. North Atlantic region were characterized by highly diverse, but poorly known communities of epifaunal and infaunal organisms. Faunal community structure was affected by water depth, sediment texture, currents, and east-west gradients. Upper slopes had greatest infaunal densities but mid-slopes were most diverse. Epifaunal diversity and densities were highest along the eastern most transect. Recolonization rates were very low, suggesting that perturbations would be long-lasting.

The overall infaunal diversity of the U.S. North Atlantic continental slope and rise region was high. A total of 1,019 species were collected from 191 box core samples, with > 50 per cent (i.e., 531 species) of the fauna being previously undescribed. Annelids dominated, accounting for 45 per cent (i.e., 435 species) of the total infauna. Important polychaete families included Spionidae, Ampharetidae, Paraonidae, Cirratulidae, and Dorvilleidae. The polychaete Aurospio dibranchiata was dominant at deep stations (2,100 m). Arthropods represented 23 per cent of the total fauna by abundance, with important orders being Isopoda, Amphipoda, Tanaidacea, and Cumacea. Mollusks, represented primarily by classes Bivalvia, Gastropoda, Aplacophora, and Scaphopoda, accounted for 15 per cent (by abundance) of all infaunal species collected. The aplacopohoran molluks Prochaetoderma yongei was a co-dominant with the sipunculan Aspidoosiphon zinnni at mid-slope stations (i.e., 1,220-1,350 m water depths).

Mid-Atlantic

Continental slope and rise fauna of the U.S. Mid-Atlantic region were characterized by a highly diverse, but poorly known, community of epifaunal and infaunal organisms. Faunal community structure was affected by water depth and topographic relief, with highest diversity observed at mid-slope depths. Temporal variability in species abundance and diversity was attributed to changes in a few dominant taxa which were altered by sediment texture differences rather than by drilling-related activities. In one downslope area, decreases in sea pen densities occurred subsequent to drilling; however, it was unclear what factors, whether natural or man made, caused the observed changes. There was no evidence of drilling-related increases in metals or hydrocarbons within the tissues of brittle stars and sea urchins analyzed.

The overall infaunal diversity of the U.S. Mid-Atlantic continental slope and rise was high. A total of 862 species were collected from 237 box core samples, with 57 per cent (i.e., 489 species) of the fauna being previously undescribed. Annelids, mostly polychaetes, dominated the samples and accounted for 45 per cent (i.e., 367 species) of the total fauna collected. Important polychaete families included Dorvilleidae, Cirratulidae, Spionidae, Flabelligeridae, and Terebellidae. Arthropods represented 23 per cent of the total fauna by abundance, with important orders being Isopoda, Amphipoda, Tanaidacea, and Cumacea. Mollusks, represented primarily by classes Bivalvia, Gastropoda, Aplacophora, and Scaphopoda, accounted for 13 per cent (by abundance) of the total species collected.

South Atlantic

The biological communities of the U.S. South Atlantic slope and rise differ from those recorded from the U.S. North and Mid-Atlantic deep sea programs. Communities differ in terms of faunal composition and their associated sediment characteristics. Collections from the South Atlantic slope and rise revealed more species and individuals than the Mid- or North Atlantic regions. In the northern regions, diversity increased with increasing water depth, while in the South Atlantic the most diverse stations were scattered over a range of depths. Apparently the distribution of substrates and currents in the southern region are responsible for the observed heterogeneity. Many of the infaunal species collected were new to science. Stations exhibiting the highest diversities were along the Cape Hatteras transect and the Charleston transect. Sediments and organisms were found to be uncontaminated by hydrocarbons or trace metals.

Analysis of the deep-sea benthic and infaunal communities off North and South Carolina has revealed one of the richest and most diverse on the U.S. Atlantic slope and rise. Infaunal samples collected during this survey yielded a total of 1,202 species, including 40 per cent of which were new to science. The highest diversity was recorded at off Charleston, South Carolina in 800 m water depths. Annelids, mostly polychaetes, numerically dominated the collections. Arthropods were second in abundance, followed by mollusks. Cluster analysis revealed community differences in depth and along depth contours. Differences occurred along the contours from cape Hatteras, North Carolina to Charleston, South Carolina confirming the presence of a zoogeographic barrier. Wet weight analysis of infauna suggested a general decrease in infaunal biomass with increasing depth.

Final Report:

Studies of biological processes on the U.S. North Atlantic slope and rise. (N. Maciolek, J.F. Grassle, B. Hecker, B. Brown, J.A. Blake, P.D. Boehm, R. Petrecca, S. Duffy, E. Baptiste, and R.E. Ruff; 1987).

Availability:

Available from NTIS:

North Atlantic	Vol. I	PB88-196522/AS
	Vol. II	PB88-196514/AS
Mid-Atlantic	Vol. I	PB88-182845
	Vol. II	PB88-183090
South Atlantic	Vol. I	PB87-214342
	Vol. II	PB87-214359

Other Publications/Reports:

Blake, J. 1986. Biological processes of the U.S. South Atlantic continental slope and rise. *In: Proceedings of First Annual Atlantic OCS Information Transfer Meeting (ITM), Washington, DC.* pp. 78-79.

Brown, B. 1987. A new genus and species of Capitellidae (Polychaeta) from the Atlantic coast of the United States. Biological Society of Washington, Bulletin No. 7. pp. 56-61.

Hecker, B. 1987. Biological characterization of the northern Blake Plateau. *In: Proceedings of Second Atlantic Outer Continental Shelf Region Information Transfer Meeting (ITM), Washington DC.* pp. 63-66.

Hilbig, B. In Press. 1974. Reconsideration of the genus *Exallopus jumars*. (Dorvilleidae, Polychaeta) with descriptions of two new species from the western North Atlantic. *In: Proceedings of the Second International Polychaete Conference, Copenhagen, 1986.*

Maciolek, N.J. and J.A. Blake. 1987. The study of biological processes on the North, Mid-, and South Atlantic continental slope and rise. In: *Proceedings of Second Atlantic Outer Continental Shelf Region Information Transfer Meeting (ITM), Washington, DC.* pp. 43-46.

Maciolek-Blake, N. 1986. Study of biological processes on the U.S. North and Mid-Atlantic slope and rise. In: *Proceedings of First Annual Atlantic OCS Information Transfer Meeting (ITM), Washington, DC.* pp. 22-23.

Ruff, R.E. and B. Brown. In Preparation. A new species of *Euchone* (Polychaeta: Sabellildae) from the Northwest Atlantic, with comments on growth-related variability.

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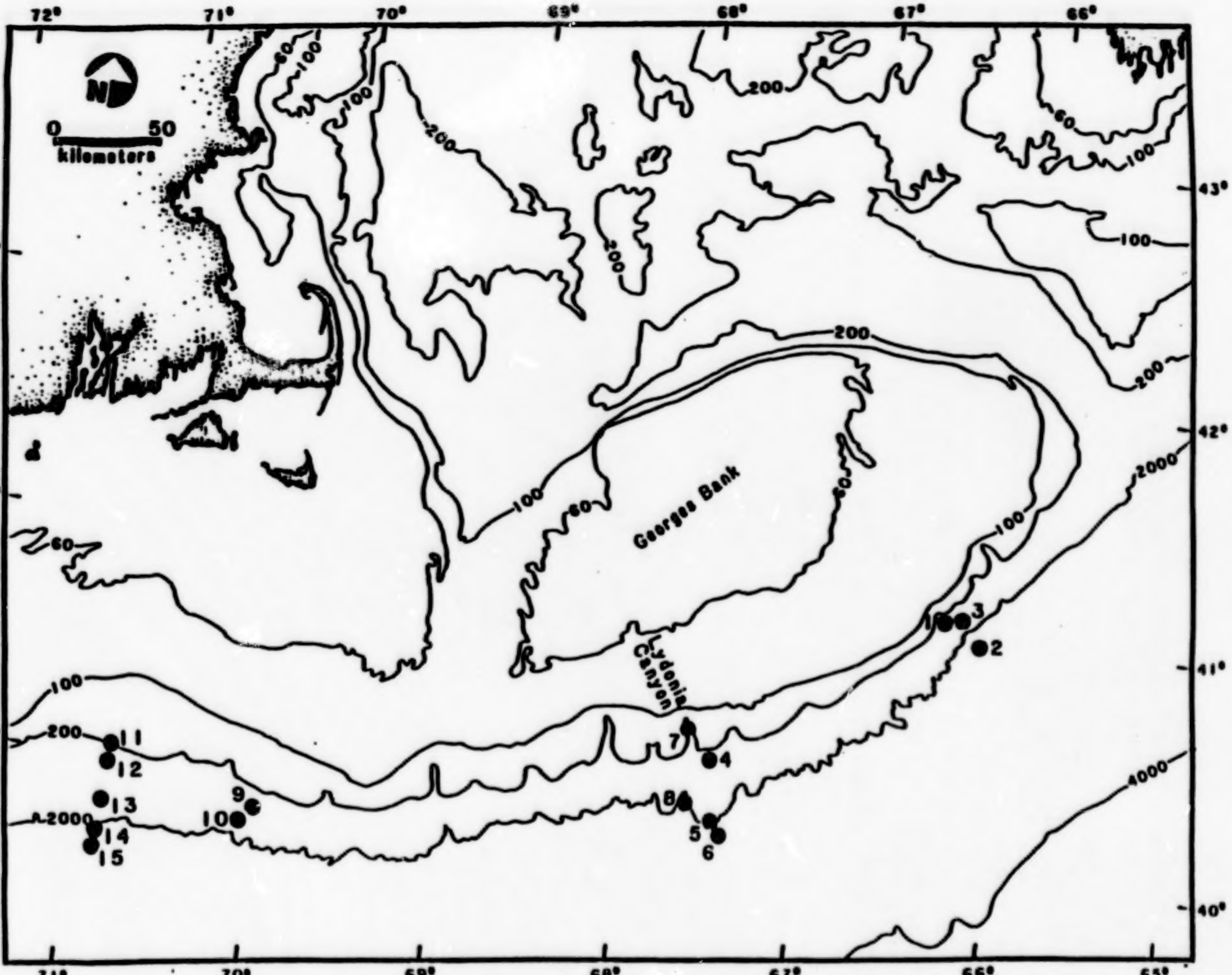

Figure 32. Station locations on the continental slope and rise for the U.S. North Atlantic study area. (Source: MMS Contract No. 14-12-0001-30064).

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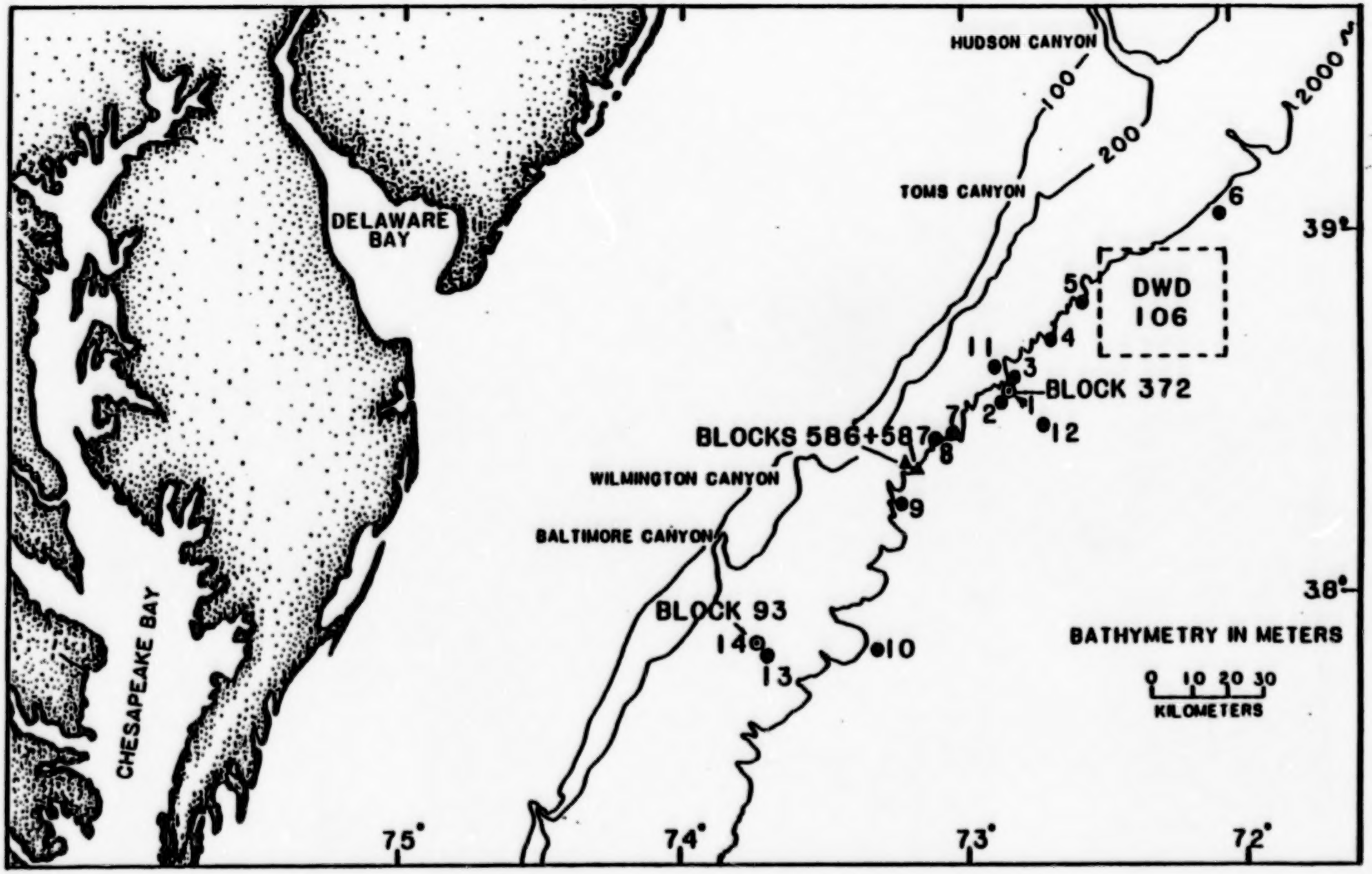

Figure 33. Station locations on the continental slope and rise for the U.S. Mid-Atlantic study area. (Source: MMS Contract No. 14-12-0001-30064).

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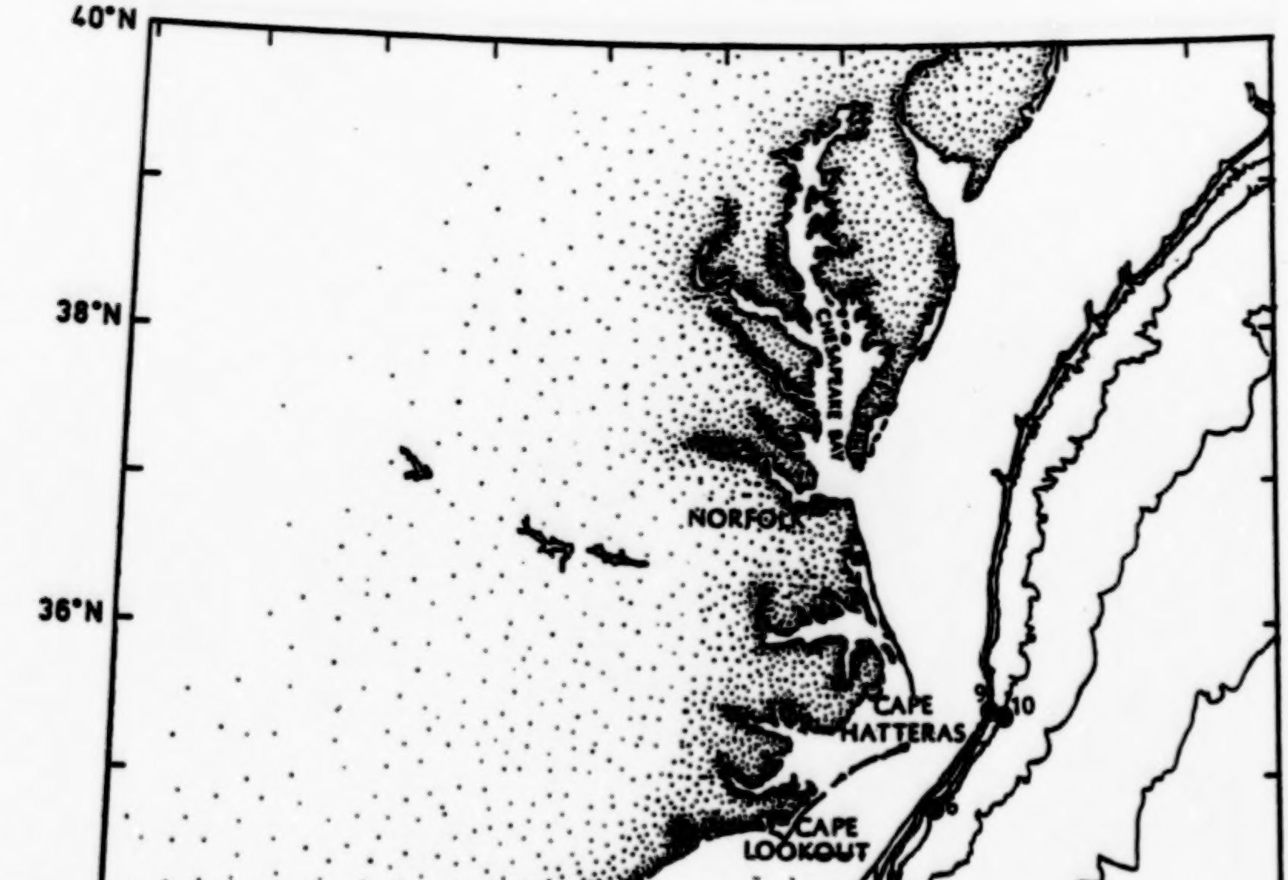

Figure 34. Station locations on the continental slope and rise for the U.S. South Atlantic benthic studies. (Source: MMS Contract No. 14-12-0001-30064).

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MMS INTERAGENCY AGREEMENT NO. 14-12-0001-30197

Title: Analysis of Trace Metals in Bottom Sediments in Support of Deep-Water Biological Processes Studies on the U.S. Atlantic Continental Slope and Rise, Year 1

Date: July 1984 - July 1987

Cost: $372,385

Prime Contractor:
U.S. Geological Survey (USGS)
Woods Hole, Massachusetts 02543

Chartered Research Vessels:
(see Contract No. 30064)

Program Manager:
Michael Bothner

Principal Participants:
Michael Bothner

Contracting Officer:
Jeffrey P. Petrino

COTR: Rosalind E. Cohen
Alyce T. Fritz

Objectives:
The program incorporates a multidisciplinary research approach. Overall program objectives will be accomplished by combining the expertise of several independent research teams. Overall objectives are as follows:

1. Characterize predrilling biological, geological, and chemical properties of benthic environments at a limited number of stations in the general vicinity of an exploratory drilling rig in each of the three study areas.

2. Monitor potential changes in these properties with time and determine whether the changes are caused by drilling-related activities or whether they are the result of other phenomena including natural temporal or spatial variation.

3. Determine the distribution and fate of discharged drilling-related materials that have accumulated above background levels.

4. Estimate recovery rates of deep-sea benthic communities potentially impacted by drilling-related activities.

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Summary:
This study is part of a multidisciplinary program conducted along the entire continental slope and rise off the Atlantic states to characterize the biology, chemistry, and geology of the sea floor prior to exploratory drilling for petroleum. They are used to help predict the fate of sediment reactive contaminants introduced to the water column by future development activities.

North Atlantic

Sediment samples collected during the first three cruises to the continental slope and rise off the North Atlantic states were analyzed for 12 metals (Al, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, V, and Zn). The metal concentrations are lower than those reported for world average shales, indicating an absence of major contamination. At most locations, Pb is slightly enriched in the surface sediments compared to deeper sections of sediment cores. This enrichment is probably related to onshore burning of gasoline containing lead additives. The potential biological effects of this enrichment (about 30%) cannot yet be evaluated. there is a positive correlation between the concentration of metals and the concentration of silt and clay.

Lead-to-aluminum ratios are generally higher in sediments from the axis of Lydonia Canyon than from the adjacent slope. This finding appears to support the hypothesis that scavenging of metals from the water column may increase in the axis of the canyon as a result of the enhanced resuspension of bottom sediment documented in a previous study.

Mid-Atlantic

The concentration of 12 metals (Al, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, V, and Zn) were measured in sediments over a two year period in order to evaluate the impact of drilling mud discharges on the continental slope off the Middle Atlantic states. Barium, a major element in drilling mud, was the only element found to increase in concentration as a result of drilling and only as stations adjacent to drilling rigs. The small changes (32% or less) were measured only in some of the replicate samples, indicating a patchy distribution of the Ba introduced by drilling. The small elevations in individual replicated did not greatly influence the average values of Ba concentration, which showed no systematic change with time. There was no evidence of accumulating drill cuttings in the sediment cores analyzed.

The strongest signal from drilling mud was observed in sediment trap samples obtained within the upper 850 m of the water column on a subsurface mooring 2.4 km southwest of the drilling rig in Block 372. Discrete particles of barite were observed in trap samples and in bottom sediments by means of scanning electron microscope. The occurrence of the largest particles in traps suggests fall velocities consistent with a modified Stokes model. Smaller particles may settle as biologically produced aggregates.

South Atlantic

Sediment samples collected on three cruises to the continental slope and rise off the South Atlantic states were analyzed for 12 metals (Al, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, V, and Zn). The metal concentrations are lower than those reported for world average shales, indicating an absence of major contamination. At some locations, Pb is enriched in the surface sediments by about a factor of 2 higher than deeper sections of sediment cores. The maximum concentration of Pb is only 17 ppm. This enrichment is probably related to onshore burning of gasoline containing lead additives. The potential biological effects of this enrichment cannot yet be evaluated. There is a positive correlation between the concentration of metals and the concentration of silt and clay.

Lead inventories at stations at the northern limit of the studied area are 5-10 times higher than predicted from the estimated atmospheric flux over the last century. Biological, chemical and physical processes which enhance metal scavenging from seawater must be relatively intense to account for the high inventories.

Final Report:

Analysis of trace metals in bottom sediments in support of deepwater biological processes studies on the U.S. North Atlantic continental slope and rise. (Bothner, et atl.; 1987).

Availability:

Available from NTIS: Final Report
North Atlantic - PB88-107560/AS
Mid- Atlantic - PB87-194387
South Atlantic - PB87-200051/AS

Other Related Contracts Within This Study Program:

14-12-0001-30064 (Parts A and B)

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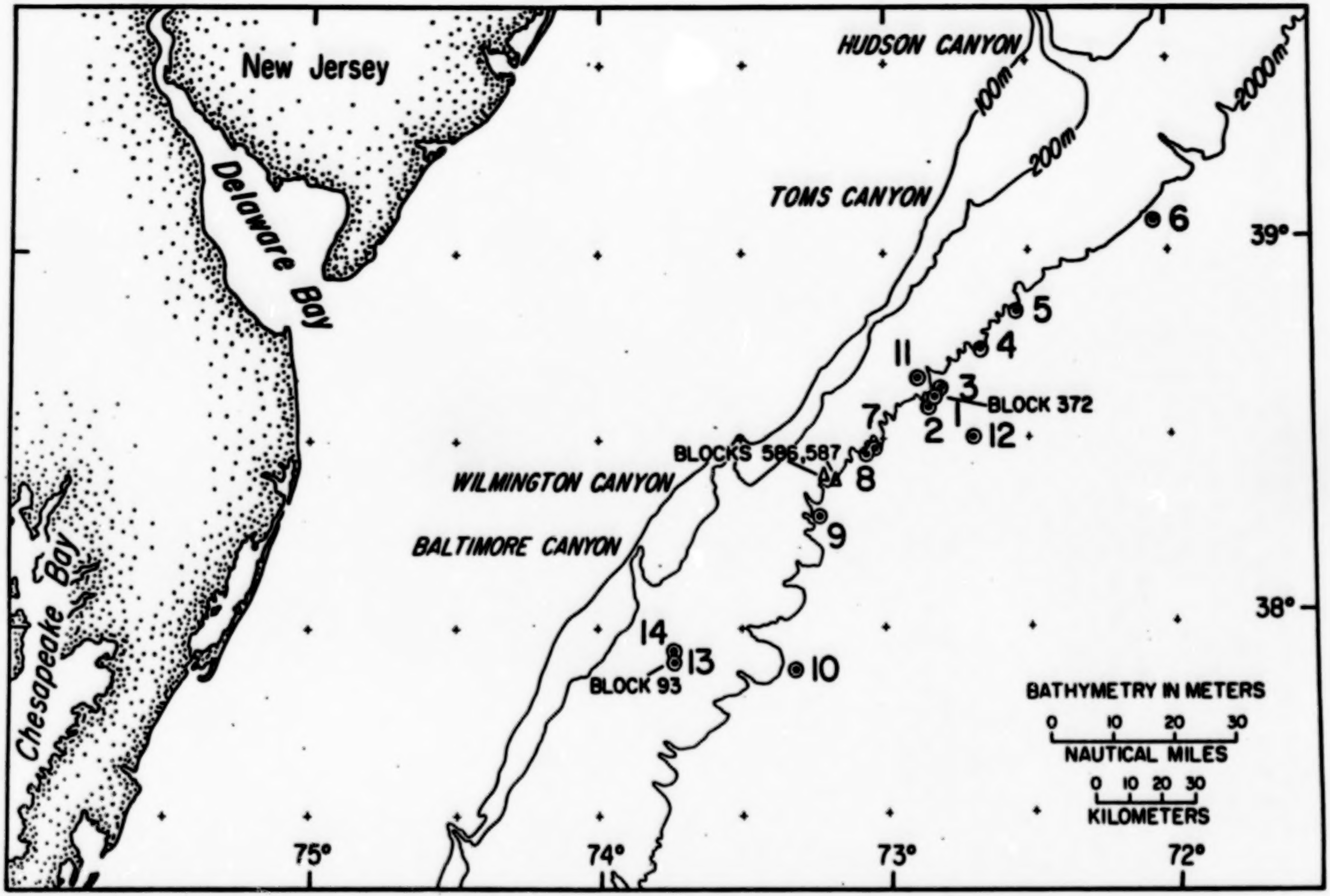

Figure 35. Station locations on the U.S. Mid-Atlantic continental slope and rise. (Source: MMS Contract No. 14-12-0001-30197).

Multiregional and National Studies

Oil Spill Studies

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BLM CONTRACT NO.: 08550-CT5-12

Title: Tamano Oil Spill Study

Date: 1 July 1974 - 21 September 1977

Cost: $28,000

Prime Contractor:
State of Maine
Department of Marine Resources (MDMR)
State House
Augusta, Maine 04330

Subcontractors/Cooperating Institutions:
Bowdoin College (BC)
Bigelow Laboratory (BL)

Program Manager:
Spencer Apollonio (Commissioner MDMR)

Principal Participants:
E. Gilfillan (BL)
D.W. Mayo (BC)
D.S. Page (BC)

Contracting Officer:
Vernon F. Ehlerding
Jeffrey P. Petrino

COTR: Edward Tennyson
Eiji Immaura

Key Words:
clams; oil spill-effects; effects of oil, hydrocarbons

Objectives:

1. Estimate the amount of damage done by Tamano oil to the soft shell clam industry of Casco Bay.

2. Estimate the rate at which recovery from the Tamano oiling has proceeded.

Summary:
The report describes the effects of the Tamano oil spill in Casco Bay, Maine on the soft shell clam (Mya arenaria). A comparison between oil-affected clams and organisms from a clean site showed a 50 per cent decrease in growth of the affected clams. Carbon flux measurements further indicated that the methods employed in the study are sensitive measures of stress exhibited by Mya arenaria to low levels of hydrocarbon contamination. When dealing with low concentrations of highly weathered oils, perhaps from several sources, total hydrocarbon content of either sediments or animal tissues are not valid measures of stress imparted to Mya arenaria.

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Of all quantities determined, the estimated relative amounts of lower molecular weight hydrocarbons present in the tissues of Mya arenaria correlate most closely with reductions in carbon flux and hence, stress imparted to the clams. In the situation studied, the estimated concentrations of low molecular weight aromatic hydrocarbons in the clam tissues were small. This leads to the conclusion that low concentrations of low molecular weight aromatic hydrocarbons in clam tissues can cause large reductions in carbon flux.

The fact that both the leaching index and the carbon flux values required similar changes in the ranking of the sites when the total information was compiled is further evidence of an interconnection between these two measurements. It would appear, therefore, that based on a significant correlation coefficient that a potential relationship between the soft shell clam carbon flux and hydrocarbon concentrations of moderately "low molecular weight residues" in the sediments exists. Future studies of the effect of these oil residue fractions would seem warranted. The carbon flux data appear to indicate that the soft shell clam is exceedingly sensitive to certain components contained in these oil fractions. Samples from Fort Williams and Willard Beach were analyzed and indicated that the surface sediments of these two exposed beach locations appear to have reached a relatively constant background level within three to eight weeks of the original spill. The data suggests that rather rapid dissipation of #6 oil will occur in exposed locations in Casco Bay provided that deep penetration of the sediments does not occur and that asphalt pavement formation did not take place. It would appear that, except for the most heavily oiled and sheltered intertidal zones in which deep penetration of the sediments had occurred, the dissipation of the Tamano spill in Casco Bay would be essentially complete during the fourth or fifth year.

Final Report:

Effects of the Tamano spill on the marine environment. (D.W. Mayo, D.S. Page; 1975).

Availability:

A review copy is available from the Minerals Management Service, Herndon, Virginia.

INTERAGENCY AGREEMENT NO. AA550-IA7-09

Title: An Environmental Study of Possible Impacts of the Argo Merchant Oil Spill

Date: November 1977 - November 1978

Cost: $170,000

Prime Contractor:
National Oceanic and Atmospheric Administration (NOAA)

Subcontractors/Cooperating Institutions:
U.S. Coast Guard
Environmental Protection Agency
Langley Research Center
Wallops Flight Center
U.S. Geological Survey
U.S. Navy
Division of Fisheries and Game (Massachusetts)
Manomet Bird Observatory
Marine Biological Laboratory
University of Rhode Island
University of Southern California
Massachusetts Institute of Technology
Woods Hole Oceanographic Institution
Aero-Marine Services, Inc.
Development Sciences, Inc.
Discover Flying
EG&G Environmental Consultants
New England Air-Photo Association
Raytheon

Program Manager:
John Robinson

Contracting Officer:
Jeffrey P. Petrino

COTR: Robert Beauchamp

Key Words:
oil spill-effects; oil tankers (transport); oil fates; oil effects on environment

Objectives:
The objective of this study was to contribute funds to a NOAA-managed study on the environmental impacts, and assessment of the Argo Merchant oil spill.

Summary:
This report documents the cooperative investigations that were undertaken immediately following the grounding of the Argo Merchant on Nantucket Shoals on December 15, 1976. It describes completed and

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continuing research on the physical, chemical, and biological processes associated with the spill, and provides a preliminary assessment of the spill as of March 1977. Neither the chemical nor biological studies were fully completed at the time of publication, as this was only a preliminary report. With this in mind the following preliminary results were presented. The oil from the Argo Merchant stayed on the ocean surface, with the exception of the "cutter stock," which entered the water column, and the whole oil that was mechanically worked into the bottom in the immediate vicinity of the wreckage. Oil in significant amounts had not been found in the sediments, except within 10 miles of the bow section of the Argo Merchant, where concentrations up to 100 parts per million were measured. Modeling efforts were successful in predicting the offshore movement of the surface oil, primarily because the movement was controlled by predominantly offshore winds while the complicated circulation of the nearshore areas and Nantucket Shoals played only a minor role. There was evidence of oil contamination in fish, shellfish, ichthyoplankton, and zooplankton populations in the area of the spill. Of the seabirds affected by the surface oil, the highest mortality was observed among Murres. The No. 6 fuel oil from the Argo Merchant formed pancakes of oil that tended to increase in thickness as they aged. These pancakes were observed to have flat bottoms, and they did not appear to be tapered towards their edges. The affected surface area was not solidly covered by a continuous film of oil but rather by thick pancakes, very thin oil film (sheen), and large open areas of water. Several direct measurements of the velocity of the oil pancakes relative to the surface water indicated that this differential velocity was about one percent of the wind speed in a downwind direction. The oil sheen appeared to be generated by the oil in the pancakes and moved at a slightly lower speed.

Final Report:

The Argo Merchant Oil Spill, a preliminary scientific report (NOAA Special Report, March 1977). (P.L. Grosse, J.S. Mattson, eds.; 1977).

Availability:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Multiregional and National Studies

Endangered Species

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BLM CONTRACT NO.: AA551-CT8-48
MMS CONTRACT NO.: 14-12-0001-29163

Title: Characterization of Marine Mammals and Turtles in the North and Mid-Atlantic Areas of the U.S. Continental Shelf

Date: 29 September 1978 - 15 March 1983

Cost: $3,704,867

Prime Contractor:
University of Rhode Island
Graduate School of Oceanography (GSO)
Kingston, Rhode Island 02881

Subcontractors/Cooperating Institutions:
Aero-Marine Surveys, Inc (AMS)
College of the Atlantic (CA)
Environmental Research Laboratories (ERL)
Marine Science Consortium (MSC)
Ocean Services, Inc. (OSI)
Provincetown Center for Coastal Studies (PCCS)
University of Maine (UM)
University of Rhode Island--Zoology Department (URI)

Chartered Research Vessels:
R/V Tioga
M/V Dolphin III

Program Manager:
Richard Edel
Martin Hyman

Principal Participants:
Nancy Bray, Turtle Assessment, Y1 (URI)
Thomas Doty, Turtle Assessment Y2-3 (URI)
Timothy Flynn, Aerial Services (AMS)
James Gilbert, Consultant (UM)
James Hain, Cetacean Assessment (GSO)
Herbert Hays, Cetacean Assessment (MSC)
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Robert Kenney, Cetacean Assessment (GSO)
Connie Knapp, Data Coordinator, Y1 (GSO)
Charles Mayo, Consultant (PCCS)
Harold Peterson, Jr., Data Consultant (ERL)
Richard Rowlett, Consultant (MSC)
Gerald Scott, Cetacean Assessment (GSO)
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William Steiner, Cetacean Assessment (GSO)
Marlene Tyrell, Data Coordinator, Y2-3 (GSO)
Howard Winn, Scientific Director (GSO)

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Contracting Officer:
Robert J. O'Connell
Jeffrey P. Petrino

COTR: Eiji Imamura

Key Words:
marine mammal study; turtle, marine (sea); migrations, behavior; population, density, estimates, distribution; shipboard survey; survey, aerial

Objectives:

1. Determine which species of marine mammals and marine turtles inhabit and/or migrate through the study area.
2. Identify, delineate and describe areas of importance (feeding, breeding, calving, etc.) to marine mammals and marine turtles in the study area.
3. Determine the temporal and spatial distribution of marine mammals and marine turtles in the study area.
4. Estimate the size of and extent of marine mammal and marine turtle populations in the study area.
5. Emphasize the above items 1-4 for those species classified as threatened or endangered by the Department of Interior and Department of Commerce.

Summary:
The final report presents the results of the initial 14 months of field studies from the Cetacean and Turtle Assessment Program (CeTAP). It provides information on the temporal and spatial distribution of the 21 species of cetaceans reported from the study area for the period November 1978 to January 1980. Areas of importance (feeding, breeding, and calving) are identified where possible, as are movements and migration routes. The study area is defined as the continental shelf waters of the northeastern United States, between the coast line and five nautical miles seaward of the 1,000 fathom isobath, and from Cape Hatteras, North Carolina, northward to Cape Sable, Nova Scotia.

The 21 species of cetaceans were divided into two groups, large whales (7 species) and small whales (14 species). The most commonly sighted large whale was *Balaeonoptera physalus*, fin whales, consisting of 47 per cent of the large whale sightings and were uniformly and widely spread over the entire continental shelf from North Carolina to West Quoddy Head, Maine. *Megapteria novaeangliae*, humpback whales, comprised 27 per cent of the large whales sightings. The minke whale, *Balaenoptera acutorostrata*, made up 10 per cent of the large whale sightings, and were in a similar habitat as *B. physalus*. *Physeter catodon*, sperm whale, was 9 per cent of the large whale sightings and was closely associated with the shelf edge and beyond. The right whale, *Eubalaena glacialis*, was spotted in 8 per cent of the large whale sightings and the area within a 100 mile radius of Cape Cod appears to be an important area. The two least common large whales were Balaenoptera borealis, (sei whale) and Orcinus orca (killer whale).

Among the small whales, Tursiops truncatus bottlenose dolphin, was the most commonly seen, 30 per cent of small whale sightings, and were frequently seen with pilot whales, Glogicephala spp. The pilot whale, Glogicephala spp., was seen in 17 per cent of the sightings and was commonly and widely distributed. The Atlantic white-sided dolphin, Lagenorhynchus actus made up 12 per cent of the small whale sightings. The harbor porpoise, Phocoena phocoena, 12 per cent of the sightings, was almost entirely limited to the continental shelf waters of New England, in an area from southeast of Nantucket, northeastward across most of Georges Bank, and throughout the Gulf of Maine. Grampus griseus, Grampus or Risso's dolphin, 11 per cent of sightings, appeared to be concentrated on the continental shelf from south of Nantucket to south of Cape Henry, Virginia. Delphinus delphis, common or saddleback dolphin, 10 per cent of the sightings, was widely distributed on the shelf edge. Stenella spp., spotted dolphins, made up 4 per cent of the sightings and were concentrated east of Chesapeake Bay south along the shelf edge to Cape Hatteras, NC. The striped dolphin, Stenella coeruleoalba, 4 per cent of the sightings, was seen along the edge of the shelf east of Delmarva Peninsula. Among the uncommon sightings were: Lagenorhynchus albirostris (white beaked dolphin), Ziphius cavirostris (Cuvier's beaked whale), Stenella longirostris (long-snouted or spinner dolphin), Steno bredanensis (rough-toothed dolphin), Delphinapterus leucas Beluga), and Mesoplodon (beaked whales).

The 1980 CeTAP Annual report contains the interpretations and syntheses of marine mammal and turtle data collected during the program's second year field effort between 10 January, 1980 and 22 January, 1981. There were no new species which had not been previously sighted in the 1979 surveys. There were some changes or differences from the previous year's sightings: 1) increased sightings of sei whales (B. borealis), 2) increased sightings of beaked whales (Z. cavirostris and Mesoplodon spp.), 3) decreased sightings of spotted dolphins (Stenella, spp.) and striped dolphins (S. coeruleoalba), and 4) more southerly sightings of harbor porpoise (P. phocena). The most common turtle seen was the loggerhead (Caretta caretta).

The sightings were in three groups: large whales, small whales, and turtles. In the large whale group, seven species were sighted: 1) Balaenoptera physalus, fin whale (51.3%); 2) Megaptera novaeangliae, humpback whale (19.2%); 3) Balaenoptera acutorostrata, minke whale (9.7%); 4) Physeter catodon, sperm whale (8.2%); 5) Eubalaena glacialis, right whale (7.3%); 6) Balaenoptera borealis, sei whale; and 7) Balaenoptera musculus, blue whale. In the small whale group, 14 species were sighted: 1) Tursiops truncatus, bottlenose dolphin (23%); 2) Phocena phocena, harbor porpoise (19%); 3) Lagenorhynchus acutus, white sided dolphin (15%); 4) Glogicephala spp., pilot whale (13%); 5) Grampus griseus, Grampus or Risso's dolphin (12%); 6)

Dephinus delphis, common or saddleback dolphin (11%); 7) *Stenella* spp., spotted dolphins (2%); 8) *Stenella coeruleoalba*, striped dolphin (2%); 9) *Mesoplodon* spp., beaked whales (1%); 10) *Lagenorhynchus albirostris*, white beaked dolphin; 11) *Delphinapterus leucas*, beluga whale; 12) *Hyperoodon ampullatus*, northern bottlenose whale; 13) *Ziphius cavirostris*, goosebeaked or Cuvier's beaked whale; and 14) *Orcinus ocra*, killer whale. In the turtle group, four turtle species were sighted: 1) *Caretta caretta*, loggerhead sea turtle (96%); 2) *Dermochelys coriacea*, leatherback sea turtle; 3) *Chelonia mydas*, green sea turtle; and 4) *Lepidochelys kempi*, Kemp's ridley turtle.

The third and final year of CeTAP studies took place in 1981. Much of the methodology described in the 1979 and 1980 CeTAP Annual Reports was continued. However, there were a number of refinements and changes. In 1981, there were four principal changes to the field studies program and corresponding data collection: 1) the shipboard platforms-of-opportunity program was discontinued at the end of 1980; 2) the sampling within the study areas was largely restricted to lease sale areas and areas of known endangered species abundance; 3) a set of replicate samples was taken in order to gauge the variability present in abundance estimation based on aerial survey data; and 4) two additional survey blocks were added (one in the Mid-Atlantic, and one in the North Atlantic) over the continental slope and rise. The resulting data collection in 1981 were from: 1) four dedicated aerial surveys (including sampling); 2) three endangered species surveys; 3) an aircraft-of-opportunity program; 4) a dedicated cruise studying respiration and dive time behavior in the Cape Cod area; and 5) opportunistic data contributed by a number of sources. This CeTAP Final Report presents the cumulative and summarized results from field studies which began in November 1978 and concluded in January 1982.

During the 39 months of CeTAP field studies, 26 distinct species or species groupings of cetaceans and 4 species of marine turtles were sighted in or nearby the study area.

The cetacean sighting data consisted of 11,156 sightings of 170,012 individuals of 26 species. Of the large whales, fin whales (*B. physalus*) and humpback whales (*M. novaeangliae*) were the more common species. Of the small whales, the bottlenosed dolphin (*T. truncatus*), harbor porpoise (*P. phocena*), whitesided dolphin (*L. actust*), pilot whales (*Blobicephala* spp.), grampus (*G. griseus*), and the saddleback dolphin (*D. delphis*) were the most common. The CeTAP results included important new findings on endangered species, among them the right whale (*E. glacialis*) and the sei whale (*B. borealis*), and gave unique, and often the only live-sighting data on several uncommon or rare species, beaked whales for example (*Z. cavirostris* and *Mesoplodon* spp.).

Throughout the field studies, not all cetacean sightings were identifiable to species. Of the total sightings, approximately 23 per cent were not identified to the species level. This percentage was made up of 998 sightings of large whales (1743 individuals) and

1520 sightings of small whales (48,180 individuals). Therefore, the species accounts represent 77 per cent of the total cetacean sightings. Given the behavior of the animals, the interplay of weather and sighting conditions, and the inherent nature of biological sampling, these results are neither unexpected nor atypical.

Over the course of the CeTAP field studies, 2820 sightings totalling 3180 individuals of 4 species of marine turtles were recorded.

Final Report:

A characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf (1982) -- second year (CeTAP, 1982). (Winn, H.E., ed.; 1982).

A characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf (1982) -- third year (CeTAP, 1982). (Winn, H.E., ed.; 1982).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS: - PB83-149906
Available from NTIS: - PB83-215855

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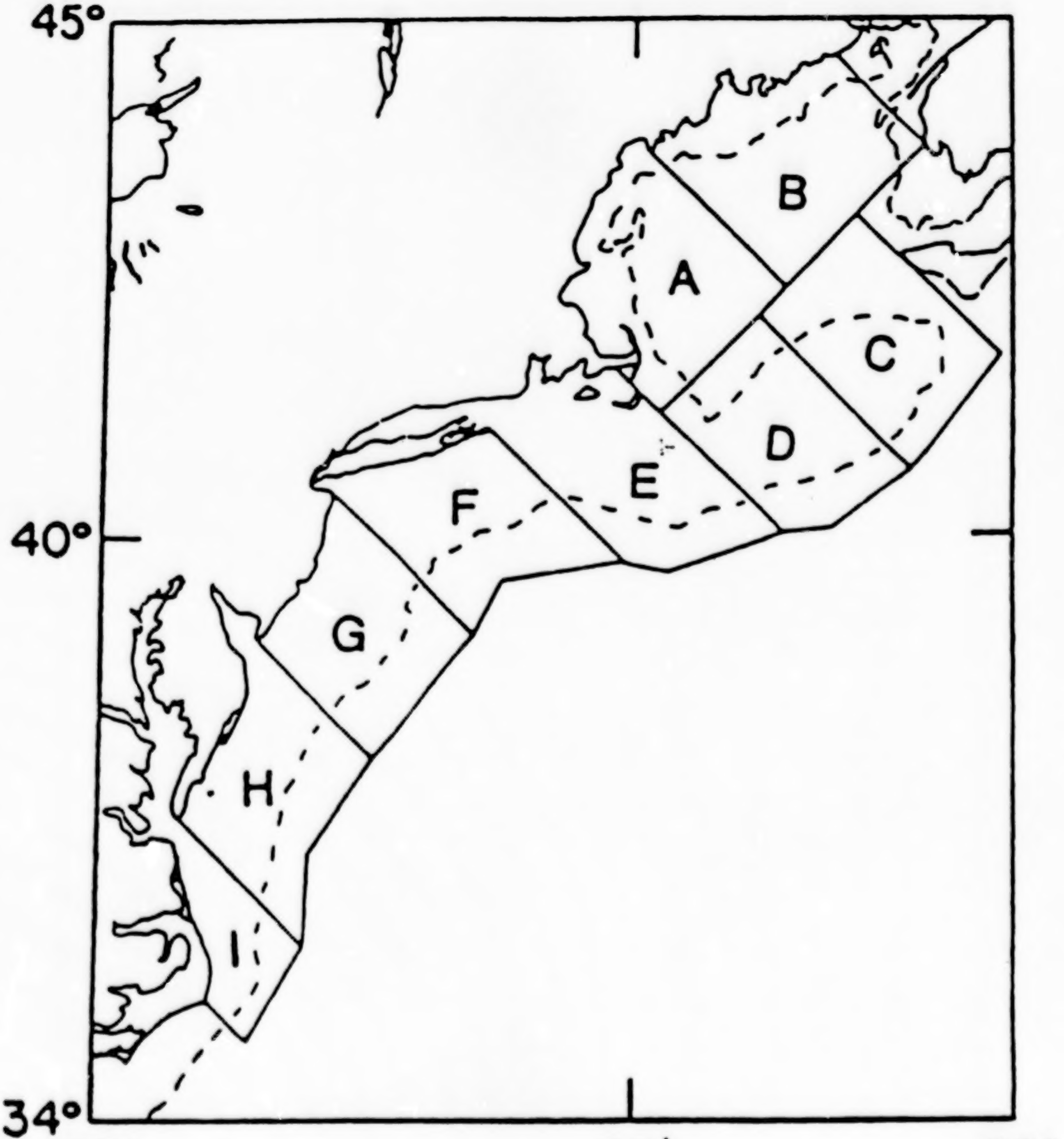

Figure 36. The study area for the CETAP program. For sampling purposes, the study area was divided into nine sampling areas depicted by the letters A through I. (Source: MMS Contract No. 14-12-0001-29163).

MMS CONTRACT NO.: 14-12-0001-30362

Title: Synthesis of Information of the Effects of Noise on Marine Mammals and Production of a Manuscript

Date: September 1987 - September 1989

Cost: $173,517

Prime Contractor:
LGL Ecological Research Associates, Inc. (LGL)
1410 Cavitt Street
Bryan, Texas 77801

Program Manager:
W.J. Richardson

Principal Participants:
R.A. Davis
P.W. Smith
P.R. Miles (BBN)
B. Wursig (MLML)
A.N. Popper
C.R. Greene (GS)
C.J. Malme (BBN)
R.J. Schusterman

Contracting Officer:
Frances Sullivan

COTR: John V. Martin
Judith M. Wilson

Key Words:
marine mammal study; noise measurements, sound production; oil rigs, platforms; literature search (bibliography)

Objectives:

1. Obtain and synthesize existing information concerning potential and demonstrated effects of noise resulting from OCS oil and gas development on marine mammals.
2. Identify gaps and weaknesses in the existing literature.
3. Produce a manuscript suitable for publication.

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BLM CONTRACT NO.: AA551-CT9-29
MMS CONTRACT NO.: 14-12-0001-29169

Title: Study on the Effects of Oil on Marine Mammals

Date: September 1982 - February 1985

Cost: $2,018,457 (Estimated)

Prime Contractor:
University of Guelph
Ontario Veterinary College
Guelph, Ontario NIG 2W1 Canada

Subcontractor:
Institute for Delphinid Research (IDR)

Program Manager:
David J. St. Aubin

Principal Participants:
Joseph R. Geraci (Scientific Director)
A.J. Souccar
M. McLean
R. Reisman (IDR)

Contracting Officer:
Jeffrey P. Petrino

COTR: Neville Chow
Alyce T. Fritz

Key Words:
marine mammal study; effects of oil, hydrocarbons; porpoises/dolphins; gray whale; humpback whale; beluga (belukha) whale; fin whale; sperm whale; sei whale; seals (seal study or seal information)

Objectives:
First year program objectives were as follows:

1. Determine the ability of cetaceans to detect and avoid an oil slick.

2. Determine the effects of oil on the integument, and the ocular, respiratory, reproductive, digestive, and excretory systems of cetaceans.

3. Evaluate the long-term impact of the above effects on cetacean survival and behavior.

4. Analyze the potential for bioaccumulation of petroleum hydrocarbons and where practical, determine the toxic threshold levels for mammalian species.

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5. Identify a range of mitigating measures which would eliminate or minimize the effects of oil pollution on marine mammals.

Second year study objectives were as follows:

1. Determine the ability of cetaceans to detect hydrocarbons representing an oil spill under nocturnal conditions, and specifically identify the cause of the avoidance reaction (tactile vs. visual) demonstrated in the first year experiments.

2. Determine the effects of oil on the filtering efficiency and structural integrity of baleen (at a minimum, bowhead, humpback, and right whales).

3. Characterize the quantity of hydrocarbons and their derivatives in marine mammal tissue.

4. Determine the extent to which delipidation occurs in cetacean skin after exposure to hydrocarbons and to determine delipidization effects on cetaceans.

5. Examine the tissue response of cetacean skin to implanted miniature "radio-tags."

Summary:

Study results indicate if a spill of crude oil occurs in a region where cetaceans are feeding and interacting, some animals may be killed--those trapped in a lead or enclosed bay, or moribund from disease. A dolphin or whale, anywhere except in the heart of a fresh spill, could not inhale enough vapor or ingest enough oil to pose any immediate threat. There may be long-term consequences that are as yet undefined. For most of the animals, however, the spill would probably not pose the kind of threat that has been popularized in the media. Surface oil avoidance tests revealed that bottlenose dolphin avoided 1 cm thick surface films regardless of type or ambient light conditions. Tactile stimulation appeared to override echolocation and chemoreception in detection of slicks. Epidermal lipid studies revealed preponderance of intracellular lipids, a unique cetacean characteristic. Long-term (35 h) gasoline exposure resulted in removal of these lipids. Lipid distribution and saturation within epidermal layers was directly related to ambient temperatures. Only one lipid extract preparation (from fin whale) suppressed growth of the bacterial pathogen Erysipelothrix rhusiopathiae. No Langerhans cells were found in cetacean epidermis, however, morphologically similar cells were detected in harp seal skin samples. The highest levels of naphthalene were in small toothed whales, particularly beluga and narwhal blubber which ranged from 6 to 21 ppm. No petroleum residue evidence was found in baleen samples from 27 whales. Experimental analyses of baleen oil fouling revealed that humpback baleen was most affected while gray whale samples were almost unaffected. Overall, baleen fouling was considered a short-term impact. Inflammatory response and wound healing in bottlenose dolphin epidermis did not include scab formation; a transformation barrier layer of epidermal cells served this purpose. The only percutaneously implanted material remaining after 12 weeks was porous polyethylene; eight other materials were extruded by the third week. There were zones of reactivity persisting around the implant, suggesting that the material had not been completely accepted.

Final Report:

Study of the effects of oil on cetaceans. (J.R. Geraci and D. St. Aubin; 1982).

Expanded studies of the effects of oil on cetaceans, part I. (J.R. Geraci, and D.J. St. Aubin; 1985).

Cutaneous response to plastic and metallic implants of potential use for marking cetaceans, part II. (J.R. Geraci, D.J. St. Aubin, G.J.D. Smith, and B.D. Hicks; 1985).

Availability:

A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS: - PB83-152991
Available from NTIS: - PB85-200947
Available from NTIS: - PB85-200954

Other Publications/Reports

Bruce-Allen, L. J., and J. R. Geraci, 1985. Wound healing in the bottlenose dolphin (Tursiops truncatus). Canadian Journal of Fisheries and Aquatic Sciences 42:216-228.

Brown, W.R., J.R. Geraci, B.D. Hicks, D.J. St. Aubin, and J.P. Schroeder. 1983. Epidermal cell proliferation in the bottlenose dolphin (Tursiops truncatus). Canadian Journal of Zoology 61:1587-1590.

Geraci, J.R. and D.J. St. Aubin. 1987. Effects of offshore oil and gas development on marine mammals and turtles. In: The long-term effects of offshore oil and gas development: An assessment and a research strategy. D.F. Boesch and N.N. Rabalais (eds.). Louisiana Universities Marine Consortium (LUMCON). U.S. National Oceanic and Atmospheric Administration, Rockville, Maryland. New York, NY: Elsevier Press, pp 12-1 - 12-34.

Geraci, J.R., D.J. St. Aubin, and B.D. Hicks. 1986. The epidermis of Odontocetes: A view from within. Part I: Anatomy and physiology. In: Research on dolphins. M.M. Bryden and R. Harrison (eds.). New York, NY: Oxford University Press, 400 p.

Geraci, J.R., D.J. St. Aubin, and R.J. Reisman. 1983. Bottlenose dolphins, Tursiops truncatus, can detect oil. Canadian Journal of Fisheries and Aquatic Sciences 40:1516-1522.

Hicks, B.D., D.J. St. Aubin, J.R. Geraci, and W.R. Brown. 1985. Epidermal growth in the bottlenose dolphin, *Tursiops truncatus*. Journal of Investigative Dermatology 85:60-63.

Smith, T.G., J.R. Geraci, and D.J. St. Aubin. 1983. Reaction of bottlenose dolphins, *Tursiops truncatus*, to a controlled oil spill. Canadian Journal of Fisheries and Aquatic Sciences 40:1522-1525.

St. Aubin, D.J., J.R. Geraci, T.G. Smith, and T.G. Friesen. 1985. How do bottlenose dolphins, *Tursiops truncatus*, react to oil films under different light conditions? Canadian Journal of Fisheries and Aquatic Sciences 42 (3):430-436.

St. Aubin, D.J., R.H. Stinson, and J.R. Geraci. 1984. Aspects of the structure and composition of baleen and some effects of exposure to petroleum hydrocarbons. Canadian Journal of Zoology 62:193-198.

BLM INTERAGENCY AGREEMENT NO.: AA851-IA0-5
MMS INTERAGENCY AGREEMENT NO.: 14-12-0001-29172

Title: Study of the Effects of Sound on Marine Mammals

Date: 11 January 1980 - September 1982

Cost: $393,600

Prime Contractor:
U.S. Navy
Naval Ocean Systems Center (NOSC)
San Diego, CA 92152

Program Manager:
Elek Linder

Principal Participants:
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COTR: J. Philip Thomas
Eiji Imamura

Key Words:
effects of noise on animal; noise measurements, sound production; endangered species information; fin whale; beluga (belukha) whale; gray whale; harbor seal; humpback whale; minke whale; right whale; sei whale; dolphins/porpoises; marine mammal study

Objectives:
The Naval Ocean Systems Center conducted field studies in areas off the Alaska, California, Gulf of Mexico, and Atlantic coasts. The objectives of this study were to:

1. Determine and characterize the various sounds emitted from outer continental shelf (OCS) oil and gas operations (exploration, development, and from related vessel traffic).
2. Characterize the sounds emitted and perceived by various species of cetaceans.
3. Evaluate the sound spectra created by human activities which could disrupt the behavior of cetaceans.
4. Determine the effects of a physical structure, such as a platform, on cetacean behavior.

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5. Propose a range of measures for eliminating or alleviating the impact(s) of sounds and physical structures from offshore oil and gas operations on cetaceans.

Summary:

The effects of noise from offshore oil and gas operations on marine mammals were assessed by a multifaceted study. The literature was surveyed for available data on noise from oil platforms and on hearing capabilities of marine mammals. Data on animal behavior around the platforms were collected by field observations and interviews with platform personnel. Direct observation of cetacean behavior in the vicinity of Outer Continental Shelf (OCS) oil and gas operations was achieved by field teams using questionnaires, identification sheets, and interviews with platform personnel. A FORTRAN computer program was developed to manage anecdotal data. Field measurements of OCS operations were made using a hydrophone, preamplifier, and magnetic tape recorder. A graphic recorder was added to this system for continuous measurements (5 days). The hydrophone was capable of responding to 0.1-Hz signals. Recorder limitation was -3 dB at 15 Hz. Each tape sample was recorded on FM (0 to 2,500 Hz) and direct (100 to 30,000 Hz) channels. Recordings were taken from 18 structures including semi-submersible drilling units, fixed multi-legged drilling and/or production platforms, and a man-made island. Offshore sites were: Santa Barbara, California; Upper Cook Inlet, Alaska; and Baltimore Canyon off New Jersey.

Evaluation of the combined data indicates that certain platforms are relatively quiet, and therefore platforms with minimal sound emission can be designed. The acoustic environment around all 18 structures exhibited components above ambient sea noise. Low frequency (4 to 8 Hz) maximum line components occurred at structures engaged in drilling or production. Sound pressure levels of the highest level components of platform noise measured at a distance of 30 m were generally in the range of 110 to 130 dB re 1 micropascal. Of the 18 structures rated, two were rated noisy, 13 moderate, two quiet, and one (the man-made island) very quiet. Noise radiated by a structure depends on the materials, configuration, size, and shape of its underwater surfaces, type of machinery power, machinery balance, and many other factors. Environmental factors included water depth and bottom type. Support vessels also produced significant increases in noise (115 to 119 dB) levels mainly due to propeller cavitation.

Additionally, according to anecdotal information, whales ignore or easily avoid platforms without appreciable behavioral alterations. The source-path-receiver model predicted that low-frequency sounds emitted from noisy platforms may be detected at ranges on the order of hundreds of kilometers under optimal conditions. For all geographic locations studied, the range of sound detection by mysticetes, odontocetes, and pinnipeds should not exceed 185 km. Actual estimates for detections were 3,200, 1,372, and 137 m for Cook Inlet, Santa Barbara, and Baltimore Canyon, respectively. Sound levels between 143 to 180 dB above threshold would be uncomfortable

for beluga whale, bottlenose dolphin, and harbor seal. Levels measured at various structures were generally well below 100 dB at 15 m. Echolocation by marine mammals occurs at much higher frequencies than sounds emitted by structures. Interference with acoustic communication is unlikely unless the receiving animal is extremely close to the platform and the sending animal is a considerable distance away.

Final Report:

Effects of noise of offshore oil and gas operations on marine mammals - an introductory assessment. Naval Ocean Systems Center Technical Report 844, September. (R.S. Gales; 1982).

Availability:

Available from NTIS:
Final Report Vol. I - ADA123699
Final Report Vol. II - ADA123700

MMS CONTRACT NO.: 14-12-0001-30293

Title: Study of Information of the Effects of Oil on Marine Mammals and Production of a Manuscript

Date: August 1986 - July 1988

Cost: $221,857

Prime Contractor:
Battelle Memorial Institute
1431 Spinnaker Drive
Ventura, California 93001

Subcontractors/Cooperating Institutions:
Battelle Ocean Sciences (BOS)
University of Guelph (UG)
Dalhousie University (DU)
University of Minnesota (UM)
Smithsonian Institute (SI)
Moss Landing Marine Lab. (MLML)
University of Alberta (UA)

Program Manager:
Eiji Imamura

Principal Participants:
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Contracting Officer:
James Shilkett

COTR: Robert Miller

Key Words:
marine mammal study; effects of oil, hydrocarbons; oil fates; pinniped study; cetacean study (general/comprehensive); sea otter; polar bear; seals (seal study or seal information)

Objectives:

1. To complete a synthesis of existing information on the effects of oil, dispersed oil, oil dispersants, and oil cleaning agents on marine mammals which migrate through or inhabit U.S. Outer Continental Shelf (OCS) planning areas.

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2. To produce a manuscript for use in OCS decision making and for serving as a general reference document for parties interested in marine mammals and oil effects research.

Summary:
Observations over the past 40 years indicate that oil-fouling can harm pinnipeds, though accounts of large-scale mortality are rare, even following major disasters near breeding colonies, such as occurred in the Santa Barbara Channel in 1969. The greater risk to pinniped populations lies more in chronic, sustained perturbations in survival and fertility, than from a single oil spill catastrophe.

The wholly aquatic nature of cetaceans protects them from exposure at the boundary between sea and land, yet offers them no avenue for escape from a spill other than to seek unspoiled waters. For pelagic species, such movements are relatively unrestricted, and consequently the risk of prolonged exposure to spilled oil is remote. Those inhabiting inshore waters, or confined to narrow open-water leads through pack ice, are considerably more vulnerable. Yet the documented cases of oil associated morality of cetaceans are so rare and equivocal as to suggest that concerns regarding their vulnerability may be more conjectural than real. The unique feeding apparatus of baleen whales would seem to represent a particularly sensitive tissue, and limited experimental evidence suggests that viscous oil in cold water can obstruct flow between the plates, at least temporarily. Beyond this, it is unlikely that oil encountered by an itinerant dolphin or whale would represent a serious threat.

Among the most vulnerable marine mammals are sea otters, whose thick coat, compulsive grooming behavior, and precarious metabolic balance ensure that even casual encounters with oil can have deleterious effects. Compounding the concern is that their inshore distribution will increase the likelihood of exposure in the event of a spill. Attempts to rehabilitate oiled otters have met with variable success, providing little reassurance that such individuals can be spared from the consequences of fouling. These concerns are shared for polar bears, with some qualification. While apparently sensitive to the metabolic effects of reduced insulation provided by an oil-fouled coast, polar bears are broadly distributed in offshore pack ice and it is not likely that a large umber of animals would be affected by a localized spill. On the other hand, the polar bear's innate curiosity and opportunistic nature might lure individuals into potentially hazardous areas around oil rigs to scavenge oil contaminated seals.

Reduced population size and continued losses resulting from fatal encounters with human activity have sensitized us to the possible effects of oil on manatees. As herbivores, they risk incidental ingestion of oil coating their preferred diet of seagrasses. Their relatively sedentary nature within restricted habitats offers little opportunity for escape. During winter months, displacement from warm embayments poses an additional threat. Beyond this, there is no evidence from field observations or stranding reports that manatees are peculiarly susceptible to incidental contact with spilled oil.

Marine mammals, except the manatee, are carnivores that rely on invertebrates or fish for sustenance. Their feeding strategies could lead to the ingestion of oil contaminated food. The concern is not that an animal would risk acute intoxication by this source, but that long term ingestion of contaminated organisms could affect its health. Such risk would depend on the prey species. For example, planktonic crustaceans assimilate hydrocarbons during a spill, and retain unmetabolized and metabolized forms for a week to 10 days thereafter. These organisms would be a source of contamination to their consumers for a relatively short time after the spill. Similarly, marine fish process assimilated hydrocarbons, excrete them fairly quickly, and as such do not represent a long term source contamination.

Final Report:

Synthesis of the effects of oil on marine mammals. (J.R. Geraci, D.J. St. Aubin, eds.; 1988).

Availability:

Available from NTIS:
PB89-117451/AS

MMS CONTRACT NO. 14-12-0001-30063

Title: Study of the Effects of Oil on Marine Turtles

Date: 30 September 1983 - October 1985

Cost: $552,135

Prime Contractor:
Florida Institute of Oceanography (FIO)
830 First Street South
St. Petersburg, Florida 33712

Subcontractors/Cooperating Institutions:
Florida Department of Natural Resources (DNR)
Shark Institute Sea World (SI)
University of Central Florida (UCF)
University of Miami (UM)
University of South Florida (USF)
Wildlife Veterinary Center (WVC)

Program Manager:
Sandra L. Vargo

Principal Participants:
Gregory D. Bossart (WVC)
Llewellyn M. Ehrhardt (UCF)
James S. Kepley (SI)
Peter L. Lutz (UM)
Molly Lutcavage (UM)
Dean M. Milliken (FIO)
Daniel K. Odell (UM)
Edward S. Van Vleet (USF)
Ross Witham (DNR)

Contracting Officer:
Jeffrey P. Petrino

COTR: William H. Lang
Rosalind E. Cohen
James Lane

Inspectors:
Robert Avent
Rosalind E. Cohen

Key Words:
endangered species information; marine sea turtle; effects of oil, hydrocarbons; oil spill effects

Objectives:
The study will conduct a preliminary literature review. Experiments will include behavioral responses of turtles to oil slicks and tarballs, effects of exposure to oil (ingestion and surface contact),

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and clinical examination of stranded marine turtles. All experiments will be supported by a detailed hydrocarbon analytical and dosing effort. Program objectives are to:

1. Determine the ability of marine turtles to detect and avoid or be attracted to tarballs and/or oil slicks.
2. Determine the effects of oil on the integument and the various physiological systems of marine turtles.
3. Evaluate the long-term impact of the above effects on marine turtle survival and behavior and analyze the potential for bioaccumulation of petroleum hydrocarbons and metabolites in marine turtles.
4. Predict--considering the known life history of sea turtles, records of past oil spills, and known climatic conditions--the possible impacts of oil on turtle nesting sites and on hatchlings, juveniles, and adults in an oil contaminated nearshore and open environment.
5. Identify a range of mitigating measures which would eliminate or minimize the effects of oil contamination on marine turtles.

Summary:

The experimental program was carried out on 3-20 month loggerhead (Caretta) and 3-116 month old green turtles (Chelonia mydas) to determine behavioral and physiological effects of oil using South Louisiana Crude Oil (SLCO) preweathered for 48 hours. The behavioral experiments indicated that both species of maine turtles had a limited ability to avoid oil slicks, but experiments to determine avoidance/attraction to floating tar balls were inconclusive. Controls (wooden balls) were struck at a greater rate than tar balls, but overall strike rates were low and interpretation complicated by feeding schedule and interspecific differences. The physiological experiments showed that the respiration, skin, some aspects of blood chemistry and composition, and salt gland function of 15-18 month old loggerhead sea turtles were significantly affected. Oil was observed clinging to the nares and eyes and in the upper portion of the esophagus and was found in the feces of all turtles in the physiological experiment. Some similar effects were found in stranded oil fouled turtles. Based on these experimental results, it was concluded that given the proper circumstances, sea turtles well be at risk in the event of an oil spill. Spills in the vicinity of nesting beaches are of special concern. Mitigating strategies for such an event are discussed. Dispersants with microbial nutrients are of interest, but they should only be used if thy are found harmless to sea turtles.

Final Report:

Effects of oil on marine turtles. (S. Vargo, P. Lutz, D. Odell, E. Van Vleet, and G. Bossart; 1986).

Availability:

Available from NTIS:

Vol. I. - Executive summary PB87-199923/AS
Vol. II. - Technical report PB87-199931/AS
Vol. III.- Appendices PB87-199949/AS

Other Publications/Reports:

Lutcavage, M., P.L. Lutz, and D.K. Odell, 1984. Study of the effects of oil on marine turtles - revised literature survey and synthesis. Report submitted to the MMS, 32 p. Appendix A.

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MMS CONTRACT NO. PO 14669

Title: Site-Specific Monitoring of Marine Mammals

Date: 15 June 1987 - 1 February 1990

Cost: $400,000

Prime Contractor:
National Science Foundation
University of Rhode Island

Subcontractors/Cooperating Institutions:
Woods Hole Oceanographic Institution
University of Washington

Program Manager:
Dr. Howard Winn

Contracting Officer:
James Shilkett

COTR: Robert Miller

Key Words: marine mammal study; right whale; cetacean study; population, density, estimates, distribution; circulation/current study; zooplankton

Objectives:

1. To investigate the physical and biological mechanisms responsible for the patterns of abundance and aggregation of the zooplankton, principally (Calanus finmarchicus in the Great South Channel (GSC).

2. To determine the abundance and distribution of zooplankton and Right Whales and their spatial and temporal associations in the GSC.

3. To describe the hydrography and current regime of the region and relationships between these cetacean and plankton distributions and aggregations in the GSC.

4. To make quantitative observations of the behavior of Right Whales in the GSC, and to obtain the necessary information to refine energy budget and estimates of Right Whale food requirements.

5. To determine the regional abundance and distribution of other cetacean species in the GSC, and to determine whether these seem to be related to the physical and biological features observed during Right Whale studies.

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Summary:

Laboratory work has focused on processing zooplankton net samples. The data from these samples will be correlated with oceanographic factors and observed Right Whale behavior. Photographic identification and matching of seven cow/calf pairs and radio-tagged animals is in progress. Six of the cows and five of the calves are matchable using the New England Aquarium and URI photographic catalog. Right Whale dive time data from radio tags was assessed. Dive times were much longer during the day when *Calanus* patches were on or near the bottom than they were at night when zooplankton layers were near the surface.

Multiregional and National Studies

Physical Oceanography

MMS CONTRACT NO.: 14-12-0001-30318

Title: Ocean Circulation Model for the U.S. Atlantic Coast and Florida Straits

Date: September 1986 - September 1990, proposed

Cost: $692,305

Prime Contractor:
Dynalysis of Princeton
219 Wall St.
Princeton, New Jersey 08540-1512

Subcontractors/Cooperating Institutions:
Science Applications International Cooperation (SAIC)
HydroQual, Inc. (HQ)

Program Manager:
H.J. Herring

Principal Participants:
D. Amstutz (SAIC)
A.F. Blumberg (HQ)

Contracting Officer:
James Shilkett

COTR: David Browne

Key Words:
circulation/current study; circulation model; oil spill model

Objectives:

1. Develop a three-dimensional, numerical, time-dependent circulation model with sufficient temporal and spatial resolution to accurately simulate meso-scale features such as short-term wind events, Gulf Stream frontal events and shelf currents along the U.S. Atlantic Coast.

2. Compile, examine, and incorporate relevant data and literature concerning surface and subsurface circulation of the waters within all Atlantic Planning Areas. This data synthesis should emphasize information concerning meso-scale circulation features within the Planning Areas. The data should be put in a format which can be readily incorporated by the circulation model identified in Objective 1.

3. Utilizing the formatted data compiled under Objective 2., devise and undertake an analysis of the skill of the selected model to determine if the model is capable of accurately depicting the general circulation, as well as

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meso-scale circulation features, evident in the Atlantic OCS Planning Areas.

4. Demonstrate the ability along with specific techniques used to interface products from the selected circulation model with the existing OSRA model.

MMS CONTRACT NO.: 14-12-0001-30350

Title: Summary of U.S. Atlantic and Southeastern Gulf of Mexico Physical Oceanographic Processes Relevant to Offshore Oil and Gas Activities

Date: September 1987 - September 1990

Cost: $528,601 (estimated)

Prime Contractor:
Battelle Incorporated

Program Manager:
Eiji Imamura

Contracting Officer:
James Shilkett

COTR: David Browne

Key Words:
circulation/current study; wind data/studies; transport (physical processes); tides

Objectives:

1. Review and synthesize available literature on all relevant physical oceanographic processes in the U.S. Exclusive Economic Zone from Tampa Florida to the Gulf of Maine.

2. Summarize physical oceanographic characteristics of the study region, including; topography, place names, special locations, major (named) currents, major fronts, water masses, hydrographic signatures, mixed layer, seasonal variations, wave climatology, wind extremes, and tides.

3. Synthesize an analysis of the time- and length- scales and associated velocity ranges of water motions associated with wind forcing, celestial tides, inertia, and mesoscale features such as eddies and wave like frontal disturbances.

4. Produce a peer reviewed manuscript as a reference for the scientific community and offshore oil and gas decisionmakers.

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MMS CONTRACT NO.: 14-12-0001-30340

Title: Evaluation of Satellite-Tracked Surface Drifting Buoys in Simulating the Movement of Spilled Oil in the Marine Environment

Date: September 1986 - March 1988

Cost: $86,925

Prime Contractor:
Applied Science Associates, Inc. (ASA)
70 Dean Knauss Drive
Narragansett, Rhode Island 02882

Subcontractors/Cooperating Institutions:
Bathy Systems, Inc. (BSI)
Oceanor Oceanographic Company of Norway (OOCN)

Program Manager:
Mark Reed

Principal Participants:
Chris Turner (ASA)
Malcolm Spaulding (ASA)
Katherine Jayko (ASA)
Donald Dorson (BSI)
Oeistein Johansen (OOCN)

Contracting Officer:
Jeffrey P. Petrino
James D. Shilkett

COTR: Newell T. Stiles
David R. Browne

Key Words:
satellite-tracked-drifters; oil transport; oil spill model; risk assessment model; transport (physical process)

Objectives:
The purpose of this study was to obtain an evaluation of satellite-tracked surface drifters for use in simulating the movement of spilled crude oil and assessing the skill of the OSRA model. The objectives of the study were:

1. Review, synthesize and summarize literature pertaining to the physical factors influencing the movement of spilled crude oil on the ocean surface.

2. Provide an annotated bibliography of the most significant publications dealing with the movement of oil on the sea surface.

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3. Define the engineering design considerations for a satellite-tracked drifting buoy, and compare them with the basic physics of spilled crude oil movement.

4. Assess whether or not any drifters, either presently available or under development, can be used in reproducing the behavior of oil spills and assessing the skill of the OSRA.

5. Recommend appropriate drifters for field trials.

Summary:

The major implications of the literature review relevant to the use of surface drifters for the simulation of oil slick trajectories are:

1. The desired drift speed remains, as before, on the order of 3 per cent of the wind speed, plus surface drift contributions from other sources such as tide and density. This is the fundamental dynamic criterion buoys must satisfy. There still is not enough information about the underlying physics to explain the observed variability around this value.

2. A buoy drifting at about 3 per cent of the wind speed will best simulate the location of the leading edge of a slick; the center of mass of the slick will be considerably behind this point. A significant wind shift during a trajectory could reverse this situation (i.e., the buoy would suddenly be at a point in the middle of or behind the main body of the slick).

3. A buoy which is a good surface follower is not likely to simulate well the trajectory of oil during storms, when the oil would be subsurface much of the time.

4. A buoy which is ideal for simulating the drift of an oil spill in open water conditions may be inadequate for tracking oil in broken ice fields, or in ice-covered waters, since buoy toughness rather than dynamics becomes most important.

5. A buoy which is designed and ballasted for short term (1 - 10 days) simulations should probably by re-ballasted for longer term simulations to account for weathering and subsequent submergence of crude oil.

An ideal drifter for simulating the drift of crude oil spilled on the sea surface would theoretically consist of and ARGOS platform transmitter terminal, antenna, and power supply sealed inside a flat, flexible plastic envelope which would dynamically mimic the behavior of oil on water. Although technically feasible, such a buoy does not exist in either the development or production phase. Existing buoys are solid bodies, and subsequent analysis was therefore focussed on definition of an optimal shape and size, using basic buoy shapes.

The project team has agreed to the following three recommendations presented in order of priority:

1. The recommended course of action would be to purchase single editions of the two most promising drifters, the Draper LCD and the Ferranti Argosphere, and test them in a variety of environmental conditions and against oil slicks and/or an IKU drifter for "ground truth."

2. Another course of action would be to design a drifter specifically for Department of the Interior purposes, based on the considerations included in this report (Section 3 in particular) and put the design out for bid. The net cost to the government is uncertain, but a superior ability to simulate oil spill trajectories might be obtained.

3. If a single existing ARGOS-compatible buoy design had to be selected immediately for large scale purchase and deployment by the Department of the Interior, the Draper Labs LCD is recommended as the best overall candidate. Major drawbacks of such an action are a) that the LCD (without drogue) will have to be ballasted since it is unstable as presently configured and b) that the drift velocity of this buoy without a drogue has not been determined empirically.

Final Report:
Evaluation of Satellite-Tracked Surface Drifting Buoys for Simulating the Movement of Spilled Oil in the Marine Environment. (ASA; 1988).

Availability:
A review copy is available at the Minerals Management Service, Herndon, Virginia.
Available from NTIS: PB88-226048/AS

Appendix

CHRONOLOGICAL LISTING OF CONTRACTS MANAGED BY THE ATLANTIC REGION ENVIRONMENTAL STUDIES SECTION

CT3-8	Socio-Economic and Environmental Inventory of the North Atlantic Region from Sandy Hook, New Jersey to the Bay of Fundy
EQHAC007	South Atlantic Socio-Economic Environmental Baseline Summary
CT5-11	Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon
CT5-12	*Tamano* Oil Spill Study
CT5-29	Georges Bank Conference - Marine Environmental Assessment
MU5-33	Mid-Atlantic Environmental Geologic Studies, Year 1
CT5-42	Environmental Data Acquisition and Analyses - Mid-Atlantic OCS (First Year Benchmark Study)
CT5-47	Continental Slope Environmental Information Summary - Canadian/U.S. Border to Cape Hatteras, NC.
CT5-51	Tourism - Related Economic Data at the County Level
CT6-01	Evaluation of Regional Economics Effects of Offshore Oil and Gas Production in Mid-Atlantic OCS-Harris Model
IA6-3/29007	Meteorological Buoy Monitoring Network/ South Atlantic Data Buoy
CT6-5	South Atlantic OCS Studies Conference
IA6-9	Preparation of EIS for Baltimore Canyon OCS
IA6-12	Mid-Atlantic Physical Oceanographic and Meteorological Study
CT6-25	Socio-Economic Model Run
CT6-26	Socio-economic Model Run (April 1976)
MU6-29	North Atlantic Geological Studies, Year 1
CT6-45	A Summary and Analysis of Environmental Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras
CT6-50	EG&G New England Physical Oceanography, Year 1

CT6-51	New England Outer Continental Shelf Environmental Benchmark Study
CT6-53/29159	Raytheon New England Physical Oceanography, Year 1
MU6-56	South Atlantic OCS Geological Studies, Year 1
CT6-62/29129	Second Year Benchmark Studies for the Middle Atlantic Region.
CT7-2/29130	South Atlantic OCS Benchmark Study
IA7-9	ARGO Merchant Oil Spill Study
CT7-16	South Atlantic OCS Physical Oceanography Literature Synthesis
CT7-29/29133	South Atlantic OCS Physical Oceanography Field Study, Year 1
MU7-31	Mid-Atlantic Geologic Studies, Year 2
IA7-35	NMFS Middle Atlantic Biological Baseline Studies
CT7-39/29004	South Atlantic OCS Literature Synthesis
MU8-13	South Atlantic OCS Geological Studies, Year 1
IA8-14	Georges Bank Climatological and Oceanographic Analysis
CT8-18	Summary and Analysis of Cultural Resource Information from the Bay of Fundy to Cape Hatteras
MU8-21	Mid-Atlantic Geologic Studies, Year 3
MU8-24	North Atlantic Geological Studies, Year 2
CT8-25	South Atlantic OCS Hard Bottom Study
CT8-32/29135	Benthic Recolonization Study under Simulated Oil Spill Conditions in the Mid-Atlantic OCS Area
CT8-34	Physical Oceanographic Modeling for the South Atlantic - Evaluation Study
IA8-37	South Atlantic OCS Data Buoy, FY'78-81'
IA8-39	South Atlantic OCS Satellite Oceanography
CT8-40	South Atlantic Cultural Resources Evaluation Study
CT8-46	EG&G New England Physical Oceanography Year 2

CT8-47/29162	Raytheon New England Physical Oceanography Year 2
CT8-48/29163	North and Mid-Atlantic Marine Mammals and Turtles Study (CeTAP)
CT8-49/29164	Canyon Assessment Study in the Mid- and North Atlantic Areas of the U.S. OCS
CT8-52/29138	South Atlantic OCS Physical Oceanography, Year 2
MU9-4	Environmental Geology Studies - North and Mid-Atlantic
CT9-5/29165	Study of Crude Oil on the American Lobster
MU9-8/29166	Marine Habitat Mapping and Pipeline Hazard Assessment
IA9-24/29012	South Atlantic OCS Physical Oceanography Data Collection
CT9-26/29167	Assessment of Space and Use Conflicts on the U.S. OCS between the Oil and Gas Industry and Commercial and Recreational Fisherman
CT9-27/29168	South Atlantic OCS Area Living Marine Resources Study, Year 1
CT9-29/29169	Study of the Effects of Oil on Marine Mammals
CT9-32/29170	Application of a Coastal Circulation Model to the South Atlantic Outer Continental Shelf
IA0-5/29172	The Effects of Sound on Marine Mammals
CT0-12/29173	South Atlantic OCS Physical Oceanographic Field Studies, Year 3
MU0-16/29175	Blake Plateau Hazards Mapping Study
MUO-18/29175	North and Mid-Atlantic Environmental Geologic Studies
CT0-35/29176	Blake Plateau Bottom and Mid-Water Current Study (30`N), Year 1
CT0-59/29178	Study of Physical and Biological Processes of Canyons and the Continental Slope in the North and Mid-Atlantic U.S. Outer Continental Shelf
CTO-75/29181	Assessing the Impacts of Oil Spills on a Commercial Fishery
IA1-15/29183	Hazards Mapping Study

IA1-17/29184	North and Mid-Atlantic Environmental Geologic Studies
CT1-18/29185	South Atlantic OCS Area Living Marine Resources Study, Year 2
CT1-25/29186	South Atlantic OCS Physical Oceanographic Field Studies, Year 4
CT1-33/29187	Blake Plateau Bottom and Mid-Water Current Study (36°N), Year 2
CT1-39/29188	Interpretation of Physical Oceanography of the Georges Bank
CT1-68/29189	North Carolina Fisheries and Environmental Data Search and Synthesis Study
CT1-69/29190	Analysis of Historical Benthic Infaunal Samples from Georges Bank
CT2-7/29192	Georges Bank Benthic Infauna Monitoring
IA2-18/29194	The Analysis of Trace Metals in Bottom Sediments - Georges Bank Monitoring Program
CT2-25/29195	Environmental Impacts of Utilizing Pipeline Corridors in the Mid-Atlantic
IA2-26/29196	Atlantic Geological Studies
CT2-33/29198	Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in Benthic Fauna - Georges Bank Monitoring Program
CT2-41/29199	Alternative Modes for Transporting OCS-Produced Oil and Natural Gas
CT2-47/29200	An Environmental Summary of the U.S. Atlantic Continental Slope and Rise
CT2-61/29201	Atlantic OCS Physical Oceanography Synthesis, Year 5
CT2-62/29202	Blake Plateau Current Measurements Study, Year 3
CT2-85/29203	South Atlantic Outer Continental Shelf Circulation Model, Phase III
30001	Analysis of Hydrocarbons in Bottom Sediments and Analysis of Hydrocarbons and Trace Metals in Benthic Fauna as a part of the Second and Third Years Georges Bank Monitoring Program

30025	The Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediments during the Second Year Monitoring Period
30063	Study of the Effects of Oil on Marine Turtles
30064	Studies of Biological Processes on the U.S. Atlantic Slope and Rise
30066	Study of Physical Processes on the U.S. Mid-Atlantic Continental Slope and Rise
30082	Florida Atlantic Coast Transport Study (FACTS)
30152	Analysis of Physical Oceanography Data Offshore North Carolina (March 1984)
PO 10244	Effects of a Natural Disturbance on a Continental Shelf Live-Bottom Community (December 1984)
30153	Georges Bank Monitoring Program: Analysis of Trace Metals in Bottom Sediment, Year 3
30180	North Atlantic Slope and Canyon Study
30195	Information Transfer Meeting
30197	Analysis of Trace Metals in Bottom Sediments in Support of Deep-Water Biological Processes Studies on the U.S. Continental Slope and Rise
30293	Study of Information of the Effects of Oil on Marine Mammals and Production of a Manuscript (August 1986)
30318	Ocean Circulation Model for the U.S. Atlantic Coast and Florida Straits (September 1986)
30336	Synthesis of Knowledge of the Potential Outer Continental Shelf Impacts from Oil and Gas Activities on Fisheries (September 1986)
30337	Proceedings of Second Atlantic Outer Continental Shelf Region Information Transfer Meeting
30340	Evaluation of Satellite-Tracked Surface Drifting Buoys in Simulating the Movement of Spilled Oil in the Marine Environment (September 1986)
30349	Gulf Stream Frontal Dynamics Study Offshore North Carolina (March 1987)
30350	Summary of U.S. Atlantic and Southeastern Gulf of Mexico Physical Oceanographic Processes Relevant to Offshore Oil and Gas Activities (September 1987)

30362	Synthesis of Information of the Effects of Noise on Marine Mammals and Production of a Manuscript (September 1987)
30369	Workshop to Facilitate Efforts to Develop Effective Systems for Tracking Endangered Whales (1987)
30417	Synthesis of Available Biological, Geological, Chemical, Socioeconomic, and Cultural Resource Information for the South Florida Area (September 1988)
30430	Submarine Canyon Workshop for the North Atlantic (September 1988)
30480	Third Atlantic Outer Continental Shelf Information Transfer Meeting

*U.S. GOVERNMENT PRINTING OFFICE:1989-247-665:00661

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

March 3, 1849

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